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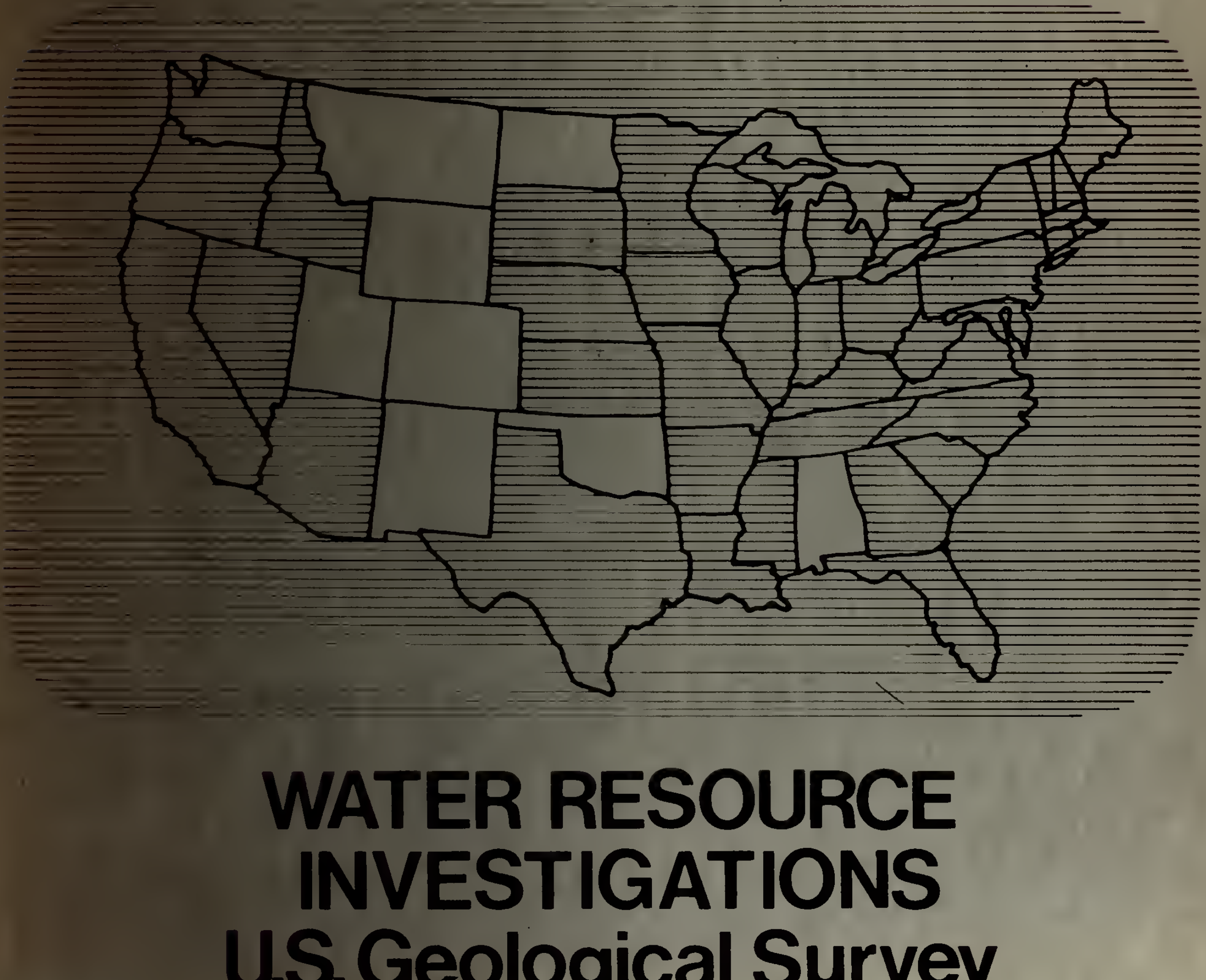
WORK PLAN
FISCAL YEAR 1978

EMRIA



WATER RESOURCE INVESTIGATIONS

U.S. Geological Survey
Bureau of Land Management

U.S. DEPARTMENT OF THE INTERIOR
March 3 1849

1978

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FY78 EMRIA WATER RESOURCES PROGRAM

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State	Activity	Page	Cost
Alabama	I. Hydrologic Modeling	1	$148,100
Colorado	I. Hydrologic Modeling	9	
	B. Study Watersheds	9	
	1. Foidel Creek	9	52,500
	2. Taylor Creek	10	46,000
	3. Hayden Gulch	11	54,000
	4. Raton Mesa	12	150,000
	II. Ground-Water Levels	12	50,000
	III. Hydrology of Spoils Piles	13	61,800
	IV. Hydrologic Characterization of North Park	15	52,600
	V. Hydrologic Characterization of Raton Mesa	16	90,000
	VI. Salinity Program	17	
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		Total	$641,100
Montana	I. Hydrologic Modeling	22	85,000
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	C. Study Site Monitoring	27	46,000
	V. Least Tract Site Investigation	28	93,200
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	VII. Water Quality Network Evaluation	30	40,720
	VIII. Isopluvial Mapping	31	19,000
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	A. Montana Bureau of Mines	31	72,300
	B. Montana Department of Health	32	24,000
	C. Montana State University	33	17,000
	X. Other Studies	34	
	A. Big Sheep Creek	34	5,840
	B. Reservoir Survey	34	26,000
		Total	$654,590

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	II. Objectives	38	
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	2. Continuous	39	7,000
	3. Climate Station	39	20,000
	4. Single-Stage Samplers	39	15,900
	IV. Reconnaissance Studies	40	
	A. Watershed Characterization	40	50,000
	B. Observation Wells	40	10,000
	C. Pump Testing	40	5,000
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	Total		$210,700
North Dakota	I. Hydrologic Modeling	45	
	A. Beulah Trench	45	111,250
	B. Wibaux-Beach	47	94,000
	II. Gascoyne	48	68,600
	Total		$273,850
Oklahoma	I. Hydrologic Modeling	53	64,000
	II. Operation and Maintenance	59	34,730
	Total		$98,730
Utah	I. Book Cliffs-Wasatch Plateau	62	38,500
	II. Ferron Sandstone	62	85,000
	III. White River Gage	64	12,000
	Total		$135,500

State	Activity	Page	Cost
Wyoming	I. Hydrologic Monitorigy	65	
	A. Powder River	65	52,760
	B. Green River	66	103,020
	C. Hanna Basin	67	22,980
	D. Other	68	25,950
	II. Reclamation Study Areas	69	
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	B. Red Rim	70	4,010
	C. Potter Mountain	71	8,020
	III. Drilling	72	20,000
	IV. Water Quality Sampling - Green River	73	28,500
	Total		$279,290
Office of Public Lands Hydrology		76	$140,000

List of Water Quality Parameters

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ANNUAL WORK ORDER

USGS Water Resources Division and BLM (EMRIA)
Fiscal Year 1978

AUTHORITY

The General Agreement between the Bureau of Land Management (BLM) and the Geological Survey (GS), dated August 15, 1974, is considered an integral part of the Work Plan.

PURPOSE

The purpose of this work order is to specify the nature and amount of assistance to be provided by GS to BLM under the EMRIA program during FY-78.

SCOPE

This work order includes all services to be provided by the GS under the EMRIA program to BLM in fiscal year 1978 in the States of Alabama Colorado, Montana, New Mexico, North Dakota, Oklahoma, Utah and Wyoming.

The GS will provide the services, including personnel, equipment, supplies, and facilities to conduct water resources investigations in areas designated by the BLM. Services will include installation, operation and maintenance of surface water gages, ground water wells and climate stations as well as water quality collection and analysis. Detailed descriptions of all studies in the eight states are presented in "Annual Work Plan for the BLM (EMRIA)/GS Water Resources Investigations-FY 78" which is considered an integral part of this work order.

PROCEDURE

Fiscal year 1978 is the fourth year of this cooperative effort. Some work begun in fiscal years 1975, 1976 and 1977 will be continued in fiscal year 1978, while some projects may be dropped. New studies will begin in fiscal year 1978, some of which will carry into fiscal year 79 and beyond. These decisions will be made in joint meetings among the GS district and state offices and the Denver Service Center. The annual work plan is developed by D-307 after negotiations with BLM field offices to determine needs and GS field offices to determine capabilities.

Field investigative procedures will be standard GS water resource investigation techniques.

REPORTS

Reporting will generally be standard GS report procedures with some deviations that are detailed in the Annual Work Plan.

FUNDING

BLM will reimburse GS for actual expenses incurred in providing the services covered in this work order, not to exceed $2,581,860, upon receipt of SF 1081. Details of cost items for each study in each state are presented in the Annual Work Plan. A summary of costs by state is presented below.

SUMMARY OF COST ESTIMATES BY STATE

Alabama	148,100
Colorado	641,100
Montana	654,590
New Mexico	210,700
North Dakota	273,850
Oklahoma	98,730
Utah	135,500
Wyoming	279,290
Public Lands Hydrology	140,000
Total	$2,581,860

APPROVED

U.S. Geological Survey	Bureau of Land Management
Date	Date

SUMMARY

State	Project Cost			Total Cost
	EMRIA	Salinity	MSO	
Alabama	148,100			148,100
Colorado	556,900	84,200		641,100
Montana	662,750		31,840	654,590
New Mexico	210,700			210,700
North Dakota	273,850			273,850
Oklahoma	98,730			98,730
Utah	135,500			135,500
Wyoming	250,790	28,500		279,290
OPLH	140,000			140,000
TOTALS	$2,437,320	$112,700	$31,840	$2,581,860

ALABAMA

I. Hydrologic Modeling

A. Location: The Warrior Coal Field is the principal area of study which includes parts of Walker, Fayette, Tuscaloosa, and Jefferson Counties, an area of about 3,900 square miles.

B. Objective: Collect and interpret basic data on water resources to aid the Bureau of Land Management in its responsibility for preparation of environmental impact statements and in its planning and management of coal reserves underlying Federally controlled mineral rights. The interpretation of the data collected is divided into three phases to determine the following:

1. Hydrologic characterization of selected basins.
2. Effect coal mining will have on the hydrology.
3. Assess the reclamation practices by reviewing literature and personal contacts on the various reclamation practices presently performed in Alabama; and the evaluation of data collected as a part of Federally financed coal hydrology project AL 75-034 in Jefferson County, Alabama.

C. Procedures: Twenty-three surface-water resources data collection sites have been established in selected basins in the Warrior Coal Field. Data collection started in October 1976 will be continued during the 1978 FY. Data collected at three additional sites in Jefferson County as part of AL 75-034 have also been incorporated into this project. The evaluation of these data are being used to determine seasonal changes prior to mining operations and will be continued during mining operations to assess the effect that mining has on the hydrologic system. Four basins selected for monitoring in Tuscaloosa County are Blue, Bear, Turkey, and Yellow Creeks.

1. Bear and Blue Creek basins are in an area where the surface geology is predominantly weathered sandstone and shale that occurs above the coal seams in the Pottsville Formation. Turkey and Yellow Creek basins are in an area in which there is a high percentage of unconsolidated sand of Cretaceous age overlying the coal seams in the Pottsville Formation. Mining is expected to start in these areas in 1 or 2 years, and data obtained from these basins will have transfer value to similar areas within the Warrior Coal Field.
2. Continue operation of two continuous-record stations equipped with surface water-level recorders, rain gages, automatic sediment samplers, and water-quality monitors, measuring temperature and specific conductance.

3. A network of observation wells, utilizing existing wells, was completed in FY 77. The completion of a well inventory study of the four basins selected indicates a scarcity of water wells that could be used as observation points. Test drilling (funded by USGS) is planned during FY 78 to fill the gap in existing wells to meet the needs for an adequate observation-well network.
4. Water-level measurements and water-quality sampling started on March 1, 1977 will be continued and expanded as new wells are drilled. Constituents determined at the start of sampling, semi-annually, and when significant hydrologic changes occur are noted.
5. Continue to tabulate and interpret on a current basis all water-quality, sediment, biologic, geologic, and meteorologic data pertaining to baseline conditions prior to mining and to assess any changes resulting from mining as it develops.
6. Continue to contract work with Southern Resources Mapping Corporation for aerial photography of the four basins. A total of 120 square miles was completed in February 1977 for use in the preparation of 1:24,000 base maps. The photographs will aid in determining the percentage of areas in the basin that are mined, the land use, the location of timber trails, etc.
7. Continue coordination with other agencies to avoid duplication of data collection and to inform other agencies of the objectives of the project and the data being collected. Meetings or discussions have been held with the following agencies or firms: Alabama Water Improvement Commission, Geologic Survey of Alabama, West Alabama Planning and Development Council (responsibility for 208 project, Tuscaloosa County), Bureau of Mines, and University of Alabama, Gulf States Paper Corporation, Burgess Mining Company, Warrior River Coal Company, Odell Mining Company, Brilliant Mining Company, Soil Conservation Service, Environmental Protection Agency, U.S Forest Service, MESA, Cullman Times, Sumiton News, Drummond Coal Company, Alabama Development Office. U.S. Geological Survey personnel assigned to the BLM project moved to a new office space at Wood Square in Tuscaloosa January 15, 1977. BLM personnel opened an office adjacent to this space on March 1, 1977. This arrangement is fostering close working relations between the two offices. Progress conferences are planned by the U.S. Geological Survey for BLM personnel for the purpose of reviewing status of project activities and the availability of data required for preparation of EIS statements.
8. In addition to the two continuous-record stations, six partial-record station have been established where regular monthly streamflow measurements, water quality, and biologic sampling is being done, and 18 miscellaneous stations have been established where streamflow, water quality, and sediment data will continue to be collected at least twice per year during FY 1978.

The biologic sampling phase of this study consists of measuring parameters that are indicative of the effects of acid mine drainage. The biologic program will identify the stream organisms present as well as quantify them. Currently, biologic sampling is being done in sections of streams at or near riffle areas; however, it is proposed to expand the biologic sampling program to include sampling in pools as four of the eight regularly visited sites as sediment deposition in pools will have the first noticeable effects on the biologic community. It is proposed to perform biologic pool sampling on a quarterly basis. All of the eight sites have been reviewed by biologic consultants from the Central Laboratory at Doraville, Georgia and determined to be acceptable for biologic sampling. Detailed climatic data (precipitation, temperature, humidity, and wind) will be measured for the purpose of input and calibration of models that are being developed for EMRIA studies by the U.S. Geological Survey office in Denver.

D. Current Data Collection:

1. Surface water.--Discharge, chemical quality, biologic, and sediment.
2. Ground water.-- Information on wells, aquifer yield, water use, water levels, chemical quality, water availability, occurrence, and movement.
3. Rainfall.--Distribution and chemical character.
4. The collection of data at the eight sites previously selected will continue to be done monthly and as dictated by weather conditions. As a means of expediting this phase of the project, the following summary, giving basic data needs, procedures, and manpower needs for data collection follows:

    a. Regular Monthly Data Collection and Procedures: Continue data collection and procedures as follows:

        (1) Stream discharge.--Measure each site during each visit in order to establish stage-discharge relationship throughout the flow regimen.
        (2) Sediment.--Collect sample during each visit to determine suspended sediment concentration. Additional sediment samples for particle size will be collected at predetermined intermittent intervals. Standard procedures outlined in TWRI Book 3, Chap. 2C will be used in sample collection.
        (3) Chemical quality.--Field determinations of pH, specific conductance, bicarbonate, dissolved oxygen, and temperature will be made during each visit.

(4) The regular monthly data collection program as stated above shall apply to the following sites:

Station No.	Station Name
(1) 02462600	Blue Creek near Oakman, Ala.
(2) 02462980	Yellow Creek above Northport, Ala.
(3) 02462985	Unnamed tributary to Yellow Creek near Northport, Ala.
(4) 02462990	Yellow Creek near Northport, Ala.
(5) 02463890	Dry Branch near Samantha, Ala.
(6) 02463900	Bear Creek near Samantha, Ala.
(7) 02464145	Turkey Creek near Tuscaloosa, Ala.
(8) 02462991	Tributary to Yellow Creek above Watermelon Road near Tuscaloosa, Ala.

Sediment samples will be collected in a minimum of ten verticals using the ETR method.

b. Data Collection and Procedures for Flood Events:

(1) Stream discharge.--Make as many measurements as possible in order to rate the gaging station site throughout the entire flow regimen.

(2) Sediment.--Samples will be manually collected before the rise and during the rise, peak, and recession of the peak. During the rise, peak, and recession, sampling will be done at least once each hour and in some cases as often as possible, depending on the individual rise characteristics. For stations with installed automatic sediment samplers, one sample is normally collected per day during base flow conditions; during a flood event, the samplers are to be set to collect samples per half foot change in river stage during the entire flood event. Samples will continue to be collected manually at different stages until the relationship between sediment discharge obtained sampling manually and by the automatic sediment sampler is determined. Samples will be collected in a minimum of ten verticals using the ETR method. Use standard procedures as outlined in TWRI Book 3, Chap. 2C.

(3) Chemical quality.--Depth integrated samples for chemical quality will be collected across the stream cross section at about ten verticals. For each sample, determine and record the specific conductance, pH, and temperature. If a 20 percent

change in conductance is noted between current and previous sample or a rise of 1 foot occurs, additional flood water quality variables will be sampled. A field determination of bicarbonate will be done before the rise, if time permits; otherwise, bicarbonate will be determined as part of the laboratory analysis.

The parameters and the frequency of sampling may change with time, as the data received from these sites will be evaluated on a timely basis, and changes may be made during the course of the project depending on the significance of the results.

E. Report Products: All data collected as a part of the project will be placed in computer storage on an ongoing basis. All baseline data will be published in annual reports of the U.S. Geological Survey. A progress report is scheduled for completion in September 1978 and a final report outlining baseline conditions and the effect of coal mining on the hydrology of the area will be prepared at the termination of the project. During the course of the study, interpretations of the data obtained from the project will be incorporated into papers presented to professional organizations that deal with coal mining. A review of progress of other State and Federal agencies' activities in coal mining projects will be made on a periodic basis to keep abreast of the activities so that phases of this investigation will not duplicate ongoing projects. Those agencies that are currently involved in this type of activity include the Geological Survey of Alabama, the University of Alabama Research Department, and NASA.

F. Distribution of Funds: A breakdown of expenditure of funds planned for 1978 fiscal year and the allocation of money from BLM follows:

Salaries	80,200
Travel	2,200
Aerial Photography	1,200
Data Processing	4,700
Laboratory Services	24,900
Equipment and Supplies	9,700
WOTSC	25,200
Total	$148,100 1/

1/ Does not include $51,200 from WRD for continuation of biologic work described in previous section and the increase in scope of proposed biologic work involving the sampling of pools.

ALABAMA

LIST OF WATER QUALITY PARAMETERS

Constituents to be Determined at any Time a Large Change in Chemical Characteristics Occur

Silica
Iron
Manganese
Calcium
Magnesium
Sodium
Potassium
Bicarbonate
Carbonate
Sulfide
Sulfate
Chloride
Fluoride
Nitrogen, nitrate, total
Nitrogen, total Kjeldahl
Phosphorus, total
Dissolved solids
Hardness, calcium-magnesium
Hardness, noncarbonate
Acidity
Sodium absorption ratio
Specific conductance
pH
Temperature
Color
Arsenic
Cadmium
Chromium
Cobalt
Copper
Lead
Lithium
Mercury
Selenium
Strontium
Zinc

Constituents to be Determined Semiannually

Iron
Bicarbonate
Carbonate
Sulfate
Hardness
Specific conductance
pH
Temperature

Surface-Water Chemical Quality Sampling Program

Constituent or Description	Semiannual	Quarterly	Monthly
Discharge, ft^3/s			X
Silica		X	
Iron		X	
Manganese	X		
Calcium		X	
Magnesium		X	
Sodium		X	
Potassium		X	
Bicarbonate			X
Carbonate			X
Sulfide		X	
Sulfate			X
Chloride		X	
Fluoride		X	
Nitrogen, nitrate, total		X	
Nitrogen, nitrite, total		X	
Nitrogen, total Kjedahl		X	
Phosphorus, total		X	
Phosphorus, orthophosphate		X	
Dissolved solids		X	
Hardness, calcium-magnesium		X	
Hardness, noncarbonate		X	
Acidity		X	
Sodium absorption ratio		X	
Specific conductance			X
pH			X
Temperature			X
Color		X	
Dissolved oxygen		X	
Specific conductance/sulfate			X
Aluminum		X	
Organic carbon, total	X		
Carbon, total	X		
Phenols	X		
Arsenic	X		
Boron	X		
Cadmium	X		
Chromium	X		
Cobalt	X		
Copper	X		
Lead	X		
Lithium	X		
Mercury	X		
Selenium	X		
Strontium	X		
Zinc	X		
Gross Alpha, Beta radionuclides	X		
Radium 226	X		
Uranium	X		

Surface-Water Biological Quality Sampling Program

Description	Quarterly	Monthly
Periphyton		
Agal identification		X
Chlorophyll		X
Biomass		X
Benthic Invertebrates		
Type II	X	
Algal Growth Potential		X
Phytoplankton		
Chlorophyll		X
Identification		X
Adenosine Triphosphate		X

COLORADO

I. Hydrologic Modeling

A. Objectives: The objective of this program is to define the hydrologic system of the basin, interrelating surface-water flow, ground-water movement, precipitation, and climate. The availability and quality of surface and ground water will be defined. This information will be related to present and future mining operations to assess the affects of mining on basin hydrology. This program will provide data for the total assessment of the mining.

For FY 78 the hydrologic monitoring program will be continued. Data on surface-water quantity and quality, ground-water quality and potentiometric surface levels, and area climate will be collected. Convertible Data Collection Platforms (CDCP) have been installed at the climate stations on Foidel and Taylor Creeks to facilitate more rapid and complete data collection and reduction. Available data from new observations wells from governmental and private drilling programs will be obtained for completing the area observation well network.

B. Study Watersheds:

1. Foidel and Middle Creek: Three surface-water gaging stations are operated. Discharge, water temperature, and specific conductance are continuously monitored at each station. Monthly water samples are collected at each station to be analyzed for major chemical constituents. Water samples are collected quarterly at each station and analyzed for trace metals. Monthly sediment samples are collected at the upper Foidel Creek and the Middle Creek stations. Sediment samples at the lower Foidel Creek station are collected by an automatic suspended sediment sampler.

A climatological station is operated on Middle Creek. Precipitation, air temperature, relative humidity, soil temperature, wind, and solar radiation are measured at this site. A second precipitation gage is operated on the rehabilitation study area and a third precipitation gage is installed at the mouth of Foidel Creek.

Three deep wells (about 400 feet deep) and five shallow alluvial wells (about 50 feet deep) were drilled in the study area. Two shallow wells were abandoned and six wells were completed as observation wells. Five wells drilled by the Bureau of Reclamation on the Bureau's reclamation study site are completed as observation wells. Water levels are measured quarterly in each observation well.

a. Distribution of Funds:

Salaries, Professional and Technical Assistance	26,175
Travel, including Transportation	3,500
Laboratory Analyses	15,600
Data Processing	2,500
WOTSC	4,725
Total	$52,500

2. Taylor, Wilson, Jubb Creek Basin: Two surface-water gaging stations are installed which, including two existing stations, brings the total number of gaging sites in the area to four. Operation of three gaging stations on Wilson, Taylor, and Jubb Creeks is funded by the Bureau of Land Management. Discharge, water temperature, and specific conductance are continuously monitored at each station. Monthly water samples are collected at each station and analyzed for major constituents and trace metals. Monthly sediment samples are collected at the Taylor and Jubb Creek stations. An automatic suspended-sediment sampler is installed at the Wilson Creek station.

A climatological station is operated in Wilson Creek basin. Air temperature, relative humidity, precipitation, soil temperature, wind and solar radiation are measured at this site. A second precipitation gage is operated in the head-waters of Wilson Creek. A third precipitation gage is scheduled to be installed on the Taylor-Wilson Creek divide after the Colowyo mining plan has been finalized.

One deep well (about 400 feet) was drilled in Wilson Creek drainage. Twelve additional wells drilled to bedrock by W. R. Grace, the Bureau of Reclamation, and the U.S. Geological Survey were completed as observation wells. All wells were tested to determine the hydraulic properties of the alluvial and deeper aquifers. Water levels are measured quarterly in each observation well.

a. Distribution of Funds:

Salaries, Professional and Technical Assistance	23,060
Travel, including Transportation	3,500
Laboratory Analyses	12,800
Data Processing	2,500
WOTSC	4,140
Total	$46,000

3. Hayden Gulch: For FY 78 the hydrologic monitoring program will be continued. Data on surface-water quantity and quality, ground-water quality and potentiometric surface levels, and area climate will be collected. New observation wells from governmental and private drilling programs will be obtained if available for completing the area observation well network.

This area has been chosen to complete the hydrologic network for northwestern Colorado. Hayden Gulch lies between Foidel-Middle and Taylor-Wilson creeks.

Hubberson Gulch and Watering Trough Gulch were selected as basins with proposed coal development. A third basin, Stokes Gulch, was selected as being representative of the dryland-farming areas of the region. Stokes Gulch will provide data to compare the hydrologic impacts of coal development with those of agriculture in the Yampa Basin.

Surface-water gaging stations are installed on Stokes Gulch and on Hubberson Gulch. Discharge, water temperature, and specific conductance will be continuously monitored at each station. Monthly water samples will be collected at each station and analyzed for major chemical constituents. Quarterly water samples will be collected at each station and analyzed for major constituents and trace metals. Monthly sediment samples will be collected at the Hayden Gulch stations. Sediment samples at the Stokes Gulch station are collected by an automatic suspended-sediment sampler.

A climatological station is installed in the Hubberson and Watering Trough Gulch area. Precipitation, air temperature and relative humidity are measured at this site. A second precipitation gage is installed in the Stokes Gulch basin.

Coal leases in the Hubberson and Watering Trough Gulch area are owned by Peabody Coal Co. Peabody has three existing observation wells in the basins. These were made available to the U.S. Geological Survey, as will future holes to be drilled for resource inventory. Water levels will be measured quarterly in these wells and water samples will be collected annually for analysis of major constituents and trace metals.

a. Distribution of Funds:

Salaries	26,340
Travel, including Transportation	3,500
Laboratory	16,800
Data Processing	2,500
WOTSC	4,860
Total	$54,000

4. Raton Mesa: For FY 78 the hydrologic monitoring program will include the installation and operation of two detailed site-specific study areas. The study sites will be selected based on their representativeness of areas to be surface mined and their potential for being mined within the next three to five years.

Two surface-water gaging stations will be operated at each study site. Discharge, water temperature, and specific conductance will be continuously monitored at each station. Monthly water samples will be collected at each station and analyzed for major chemical constituents. Quarterly water samples will be collected and analyzed for trace metals. Monthly and storm event sediment samples will be collected at one study site gaging station and one automatic suspended-sediment sampler will be installed at the second gaging station.

A climatological station will be installed at each study site. Precipitation, air temperature, relative humidity, wind and solar radiation will be monitored at each station. Additional precipitation gages will be placed within the study basins to measure areal and elevational variations in precipitation.

Deep and shallow alluvial wells will be drilled in the study areas to provide water quality and water-level data. Additional observation wells from governmental or private drilling programs will be obtained if available.

a. Distribution of Funds:

Salaries, Professional and Technical Assistance	26,500
Travel, including Transportation	4,000
Equipment	46,000
Laboratory	17,500
Drilling	40,000
Data processing	2,500
WOTSC	13,500
Total	$150,000

C. Reports: Interim results and data will be published in an interagency, interdisciplinary report. Final results will be published at the conclusion of the study, three to five years hence.

II. Ground-Water Level Monitoring, Coal-Bearing Formations in Colorado

A. Location: Colorado

B. Objectives: The objective of this program is to define seasonal and annual water-level fluctuations in the major coal-bearing Formations throughout the Colorado coal regions. These data are essential for mapping the potentiometric surface and for evaluating the ground-water hydrology and potential impacts of surface mining. Samples will be collected annually for comprehensive chemical analyses.

C. Report Products: A potentiometric surface map, with explanatory narrative that relates to mine dewatering and lowering of the potentiometric surface to changes in the hydrologic system that are or may be of concern to BLM, will be prepared in FY 78.

D. Distribution of Funds:

Salaries, Professional and Technical Assistance	10,500
Travel, including Transportation	5,000
Laboratory Costs	28,000
Data Processing	2,000
WOTSC	4,500
Total	$50,000

III. Hydrology and Reclamation Potential of Coal Spoils Piles

A. Location: Routt County, Colorado

B. Objectives: The objectives are three-fold. First, the hydrologic characteristics of coal spoils piles will be defined. The quantity, quality, and timing of water movement through the spoils will be examined and compared to the same parameters for undisturbed basin areas. The hydrologic data collected will be used to develop a model to predict the impact of coal development on the quantity and quality of water leaving a mined basin. In addition, the model will aid in the assessment of the reclamation potential of disturbed areas by providing a complete annual water balance for those specific areas of a basin.

The second objective will be the assessment of the use of cuttings from holes drilled in undisturbed areas to predict the water-quality changes that will occur after mining of these areas. Water-quality changes in existing spoils piles will be compared to quality changes in water passed through a column of cuttings from areas adjacent to the spoils. This technique would provide a relatively inexpensive method for predicting water-quality changes in areas to be mined. These data would then be used in the hydrologic simulation model to predict the impact of mining on total basin hydrology.

The third objective is to examine the effects of various reclamation procedures on spoils piles hydrology. Different land surface treatment and vegetative covers will be applied and evaluated as to their effectiveness in reclaiming disturbed areas, their specific water requirements, and their impact on water quality. This objective will not be examined until objective one is met.

The hydrology of spoils piles is monitored using a combination of lysimeters and observation wells. Lysimeters are installed in the upper 8 feet of the spoils profile. Five lysimeters are installed in a reclaimed spoils area and two lysimeters will be installed in an undisturbed area. A rainfall simulator is used to obtain deep percolation samples for quality and quantity analyses from four lysimeters in the spoils area. It will be used on one lysimeter in the natural area. Because the rainfall simulator produces an above-average water movement through the profile, one lysimeter in each area is used to monitor hydrologic response under natural conditions. The rainfall simulator will permit determination of the hydrologic characteristics of spoils, the validity of induced versus natural lysimeter response, and the effects of various reclamation treatment on spoils hydrology. Soil-water regimes within the lysimeter and areas adjacent to the lysimeter are monitored using access tubes and a neutron soil moisture probe.

One to three holes will be drilled in the existing spoils pile to total mined depth (about 150 feet). Three holes have been drilled to an equivalent depth in adjacent undisturbed areas. All holes will be completed as observation wells and periodic water samples will be collected for analysis of major chemical constituents and selected trace metals. Water-quality changes within the total depth of spoils will be determined from these samples. Cuttings from each hole will be collected and used to construct laboratory columns which are representative of the holes from which the cuttings came. Water will be passed through the columns at various flow rates and water samples will be collected at predetermined times during the column runs. Analyses of water samples from the column runs will be related to the results of lysimeter runs and the sample analyses for the observation wells in the spoils. Relationships developed between water-quality changes in the columns and those observed in the field will show the feasibility of a rapid, relatively inexpensive method for predicting water-quality changes in areas to be mined.

Once the hydrology of the lysimeters in the spoils area are defined, various reclamation treatments will be imposed. The rainfall simulator will be used to stress these treatments. The effects of these treatments on water use, runoff, and water quality will be determined.

C. Report Products: A U.S. Geological Survey Professional Paper will be published at the completion of this project. All data collected, procedures developed, data analyses, and model development will be reported in this publication.

D. Distribution of Funds:

Salaries	10,540
Travel	2,500
Laboratory Analysis	31,000
Lysimeter Construction	3,200
Observation Well Drilling	5,000
Data Processing	4,000
WOTSC	5,560
Total	$61,800

IV. Hydrologic Characterization of North Park

A. Location: Jackson County, Colorado

B. Objective: The objective of this program is to define the hydrologic system of the study area, interrelating surface flow, ground-water movement, precipitation, and climate. The availability and quality of surface water will be defined in this study. Ground-water data will be available from the ground-water level monitoring program. This information will be related to present and future mining operations to assess the affects of mining on basin hydrology.

For FY 78 this program will include the installation and operation of two complete surface-water monitoring stations. The stations will be located in the Canadian River drainage and will supplement existing monitoring programs in the North Platte River drainage. Discharge, water temperature, and specific conductance will be continuously monitored at each station. Monthly water samples will be collected at each station and analyzed for major chemical constituents. Quarterly water samples will be collected at each site and analyzed for trace metals. An automatic sediment sampler will be installed at each station to sample sediment discharge once a day and more frequently during storm events.

C. Report Products: All data will be published annually in "Water Resources Data for Colorado". An interpretive report will be published at the conclusion of the study, three to five years hence.

D. Distribution of Funds:

Salaries, Professional and Technical Assistance	16,120
Travel, including Transportation	4,000
Equipment	18,000
Laboratory Analyses	8,750
Data Processing	1,000
WOTSC	4,730
Total	$52,600

V. Hydrologic Characterization of Raton Mesa

A. Location: Las Animas County, Colorado

B. Objective: The objective of this program is to define the hydrologic system of the study area, interrelating surface flow, ground-water movement, precipitation, and climate. The availability and quality of surface water will be defined in this study. Ground-water data will be obtained from existing wells. New observation wells from governmental and private drilling programs will be obtained if available. These ground-water data will be collected and analyzed under Section II. All information will be related to present and future mining operations to assess the affects of mining on basin hydrology.

For FY 78 this program will include the installation and operation of five complete surface-water monitoring stations. Stations will be located to obtain region-wide surface water information. Discharge, water temperature, and specific conductance will be continuously monitored at each station. Monthly water samples will be collected at each station and analyzed for major chemical constituents. Quarterly water samples will be collected at each site and analyzed for trace metals. An automatic sediment sampler will be installed at each station to sample sediment discharge once a day and more frequently during storm events.

C. Report Products: All data will be published annually in "Water Resources Data for Colorado". An interpretive report will be published at the conclusion of the study, three to five years hence.

D. Distribution of Funds:

Salaries, Professional and Technical Assistance	25,400
Travel, including Transportation	2,500
Equipment	37,000
Laboratory Analyses	15,500
Data Processing	1,500
WOTSC	8,100
Total	$90,000

VI. Colorado Salinity Program

A. Evaluation of Salinity Potential of Mancos Shale Lands:

1. Location: Three study sites: (1) observation reservoir 4-A, Prairie Dog Site; (2) observation reservoir No. 12, Middle Basin Site; (3) observation reservoir No. 2-A, West Twin Site; in Badger Wash near Mack, Colorado.

2. Objectives:

   a. Operate the gages, April 1 - October 31 each year, collect samples, tabulate the streamflow, water quality (Schedule 1 analysis), and rain gage data. The streamflow gages will be operated on a 5-minute punch interval (with peak-stage indicator). The water sampler will be set to collect a sample every 5 minutes during the runoff period. It is estimated that about 10 samples per site be taken after the first runoff event and 3 samples per site for approximately 3 other storms per year will be collected and analyzed.

   b. Run topographic survey of each reservoir at the end of each runoff season.

   c. Equipment purchased to facilitate this contract shall become the property of BLM at the end of the study.

3. Report Products:

   a. Provide BLM with copies of all tabulated data as it is completed. All discharge and water-quality data will be published in Water Resources Data for Colorado on an annual basis.

   b. Summarizations will be compiled of total rainfall, runoff, sediment yield, and quality of water carried into the reservoir for each site and submitted to the BLM.

4. Distribution of Funds: (YA-300-08-4340-5225-SS00)

Salaries, Professional and Technical Assistance (Field, Office and Lab)	6,280
Travel	0
Vehicles	500
Supplies and Equipment	250
Data Processing (Lab Costs) and Computer Costs	5,800
WOTSC	1,370
Total	$14,200

B. Contribution of Ground Water to Salinity of Streams in the Upper Colorado River Basin:

1. Purpose: Salinities of the Colorado River and numerous tributary streams are a major concern to agricultural, industrial and public water-supply users. The frequently high salinity of these waters results in substantial economic damages each year to these users. The U.S. Bureau of Land Management (BLM) is responsible for regulation of land use, agricultural and irrigation practices, and any other use of the water on Federal lands under its jurisdiction to control the salinity of stream-flow in the Colorado River Basin. To meet this concern, the BLM is conducting a study of salinity control in the Colorado River Basin, for purposes of identifying ambient salinity levels and transport mechanisms occurring in water on public lands, and for formulating ways to control or reduce salt contribution. Towards this end, BLM needs to be able to delineate salt contributions from point and non-point sources by surface and ground waters on leased-grazing and other lands managed by them, and to distinguish these sources of salinity in streamflow from those contributed in other areas by irrigated agricultural croplands, and by industrial and other urban water users.

   A close relation commonly exists between surface water and ground water, and the interchange of ground water and surface water has an effect on water quality in many of the streams in the region. For example, inflow of saline ground water from such formations as the Mancos Shale and the Paradox Formation causes relatively large increases in the salt loads in the streamflow in various parts of the upper Colorado River basin. The purpose of this proposed study by the U.S. Geological Survey is to identify and evaluate ground-water contribution to salinity of the Colorado River and its tributaries, to be used to help the BLM carry out its function of managing water use on lands under its jurisdiction.

2. Scope: The study would be limited for the most part to salt load contributions by ground water from Colorado western-slope lands. Some areas in adjacent states, where data already exist and are available, would be included in the study. Examples of these adjacent areas would be the Green River basin in Wyoming, and Price River basin in Utah.

3. Approach: Ground-water contribution to salt loads of streamflow would be delineated into contributions by ground water from consolidated and semi-consolidated bedrock aquifers, by ground water from unconsolidated alluvial deposits along the streams, and by point-source ground-water contributions

such as springs. For the most part, ground-water inflow to the streams from the bedrock aquifers would be considered approximately constant throughout the year, and represents the bulk of the streamflow during the low-flow winter months. Salt-load contribution to the streamflow by ground water from the alluvial channel deposits is often highly variable. In many cases during the early high-flow spring months, the stream recharges the ground water and there would be a negative salt-load contribution by the ground water from the alluvial deposits to the streams. During the summer months, the greatest salt-load contribution to the streams by ground water from the alluvial deposits would occur, as bank storage of ground water from previous stream recharge in the early high-flow spring months is released back to the streams. In addition, flow of ground water in the alluvial deposits to the streams is highest during the summer months because of infiltration to the ground water of irrigation water during this period. The ground-water storage capacity of many of these alluvial aquifers is small and after irrigation season ends, the flow of ground water from the alluvial deposits to the streams quickly diminishes until a near equilibrium condition is reached between the stream channel and the ground water during the low-flow winter months.

Calculation of the salt-load contribution to streamflow by ground water would be made by a combination of ground-water measurements, streamflow measurements and analysis of irrigation surface-water diversion records. Calculation of direction, rates and chemical quality of ground-water flow discharges into the streams would be made directly from ground-water level and chemical-quality measurements. Streamflow measurements of quantity and quality of baseflow during winter months, would be used in selected cases for calculating salt-load contributions by ground water from the bedrock aquifers. In many instances timing of the project would prohibit the necessary collection of ground-water field data to directly calculate the salt-load contribution to stream-flow by ground water from the alluvial deposits. In these instances, estimates of salt-load contribution to the streamflow by the ground water from alluvial deposits would be made by indirect calculations of amount of applied irrigation water and consumptive-use requirements of the irrigated crops. The net infiltration of irrigation water to the ground water in the alluvial deposits would be assumed to all return to the stream less any ground-water withdrawals that have reduced the amount of ground water in storage. Calculation of salt-load contribution to streamflow by ground-water point sources such as at springs, would be made by direct measurement of the spring discharges and the chemical quality of this water.

For aquifers in which ground-water discharge contributes directly to streamflow, the location of recharge and discharge areas would be delineated, and the chemical quality of the associated recharge and discharge would be determined. This would enable evaluation of the effects of changes in land-use patterns on the chemical quality and quantity of the ground-water discharge to the streams. In some areas, seepage of highly mineralized irrigation return flows into aquifers can degrade the quality of ground water in those aquifers and thus add to the salt-load contribution in the streamflow by ground water. Conversely, the chemical quality of ground water in some aquifers has improved where irrigation has augmented natural ground-water recharge with lower-salinity water diverted from surface sources and thus decrease the salt load contribution to streamflow by ground water. Another consideration would be alteration of location or quantity and quality of ground-water discharge to streams caused by modified land-use patterns which may reduce ambient ground-water discharges by phaetophytes.

The study would entail aggregating all available data from regional studies, such as the evaluation of water resources of the upper Colorado River basin, (Iorns and others, 1964, 1955) and the summary appraisal of the ground-water resources of the upper Colorado Region (Price and Arnow, 1974). Additional data from regional studies by the USGS in the Yampa River basin (Steele and others, 1976a; 1976b), Green River basin (Lowham and others 1976), other western-slope studies in Colorado (Weeks and Hillier, 1977), and studies by others such as USBR-Utah State Price River basin study (Riley and others, 1977) would also provide useful information. These data would be augmented by field measurements of ground-water levels in wells, by collection and analysis of chemical quality of ground-water samples, and by seepage runs and specific conductance surveys for selected stream reaches to fill in any data-deficient areas not covered by the above studies. Field activities would also include reconnaissance of major springs that add to salt-load contribution to the streamflow by ground water (U.S. Environmental Protection Agency, 1971).

4. Product Execution and Information Products: Duration of the proposed study is one year, beginning on October 1, 1977, and ending on September 30, 1978. BLM will be consulted in the planning of the study and in selecting priority areas for salt-loading analyses. BLM personnel will assist in field activities related to the study. Oral progress reports will be given to BLM personnel upon request. Study results will be documented in a report released in one of the USGS series (open-file or WRT).

   A drafted study report will be scheduled for completion by September 30, 1978.

5. Distribution of Funds: (YA-350-08-4340-5225-SS00)

Planning Area and Stream-reach Reconnaissance, Site Selection	5,800
Field Activities (including Travel, Per Diem, Vehicle)	13,200
Data Compilation and Analysis (includes Computer Costs)	22,500
Formulation of Study Results and Writing of Report	16,600
WOTSC	11,900
Total	$70,000

MONTANA

I. Hydrologic Modeling

A. Location: Small (3-5 square mile) drainage basin in prairie environment in southeastern Montana.

B. Objectives: The USGS has developed rainfall-runoff models which accurately predict runoff from storm events in some environments. However, the models were developed for use in geologic and climatic conditions quite different from the prairie environment in southeast Montana and other environments in the western coal areas. The USGS proposes to modify existing models to be responsive to the various conditions unique to the western coal region. Montana district, in conjunction with other WRD districts and Regional research hydrologists will pursue problems related to runoff from snowmelt and/or rainfall on frozen ground more appropriate to the northern plains area. Hopefully the modified model can be calibrated for a small drainage basin to verify its suitability for this area. If successful, the model will be extremely useful in evaluating the effects of land-use changes such as strip mining or reclamation on run-off from small drainages.

C. Procedures: A small drainage basin typical of the northern plains will be selected and instrumented. Such parameters as air and soil temperature, soil moisture, wind speed, relative humidity, snow depth and water content, precipitation, and runoff will be evaluated over a three-year period. Existing rainfall runoff models will be modified to simulate conditions unique to the northern plains. Finally, the information collected will be used as input to calibrate the model and simulate runoff events.

D. Report Plans: Interim reports describing instrumentation, data collected and evaluated, will be prepared at the end of each fiscal year. A final report, prepared in cooperation with other WRD districts will be completed at the end of the 3-year study. The report will be published in the Professional Paper series to allow wide distribution.

E. Relationship to Other USGS Studies: The study compliments much of the monitoring activities now underway at several sites throughout the Fort Union Coal Region. Upon completion of the study, a model should be available which can utilize data from the existing data collection sites to simulate snowmelt-rainfall-runoff relationships. Several other WRD Districts will also be involved in modifying existing runoff models to simulate various climatic, geographic, and geologic settings. Montana's work will be closely coordinated with these Districts to minimize duplication, exchange information, and share experience and equipment.

F. Distribution of Funds:

Salaries	41,150
Travel	6,000
Computer Costs	8,400
Data Processing	8,000
Report Preparation	7,000
Space Rental	2,975
WOTSC	11,475
Total	$85,000

II. Hydrologic Characterization of Southeastern Montana Coal Areas

A. Maintain network of stream-discharge monitoring sites.

1. Objectives: Collect streamflow and water quality data at key locations to supplement other programs. The data is essential in defining runoff from potentially impacted areas, determining streamflow characteristics, and providing a data base from which future changes can be analyzed.

2. Procedure: Standard U.S. Geological Survey methods of surface-water data collection will be used to obtain data at the following stations:

a. Home Creek near Ashland
b. Nelson Creek near VanNorman
c. Prairie Elk Creek near Oswego
d. Burns Creek near Savage
e. Pumpkin Creek near Miles City
f. Mizpah Creek near Olive
g. East Fork Trail Creek
h. Tongue River below Brandenberg bridge near Ashland
i. Timber Creek near VanNorman
j. Horse Creek near Circle
k. Spring Creek near Decker
l. Hanging Woman Creek below Horse Creek
m. Prairie Dog Creek near Birney
n. Pumpkin Creek near Sonette
o. Snyder Creek near Brandenberg
p. Otter Creek near Otter
q. Glendive Creek near Glendive
r. Cherry Creek near Terry
s. Cottonwood Creek near Glendive
t. Otter Creek below Fifteen Mile Creek
u. Musselshell River near Roundup
v. Half Breed Creek at site near Roundup
w. Rehder Creek at Site
x. Fattig Creek at Site
y. East Parrot Creek at Site
z. West Parrot Creek at Site
aa. East Fork Trail Creek (4 stations)

3. Report Products: Basic records from surface-water-quality sites will be submitted to BLM annually or as mutually agreed upon. Records will be published by the USGS in an annual basic data report, "Water Resources Data for Montana". The data will be used by the USGS in preparing interpretive reports described further below.

4. Relationship to Other USGS Studies: This program will supplement and be correlated with other USGS programs of surface-water quality data collection. Other stations operated in this area include:

Redwater River at Circle
O'Fallon Creek near Ismay
Upper Seven Mile Creek near Glendive
Custer Creek near Kinsey
Crow Rock Creek near Rock Springs
Deer Creek near Glendive
Muster Creek near Kinsey
Clear Creek near Hoyt
Redwater Creek near Vida

5. Distribution of Funds:

Salaries	42,000
Lab Services	25,000
Travel	28,000
Supplies	4,600
Data Processing	5,000
District Overhead	4,400
WOTSC	17,000
Total	$126,000

III. Sediment Data Collection

A. Location: Tongue River below Brandenberg Bridge near Ashland, Montana.

B. Objectives: Collect sediment data on the Tongue River downstream from high-priority lease areas. The data is essential in defining present sediment loads in the Tongue River from which future changes can be analyzed.

C. Procedures: Suspended sediment samples will be collected and analyzed using standard USGS methods at the streamflow monitoring site on the Tongue River below Brandenberg bridge near Ashland.

D. Report Products: Basic records will be submitted to BLM annually or as mutually agreed upon. Records will be published by the USGS in an annual basic data report, "Water Resources Data for Montana".

E. Relationship to Other USGS Studies: This program will supplement and be correlated with other USGS sediment data collection programs. The USGS operates sediment stations at the following sites:

Yellowstone River at Billings
Yellowstone River at Forsyth
Tongue River at Miles City

F. Distribution of Funds:

Salaries	2,300
Travel	2,000
Laboratory Services	1,990
Data Processing	200
Space Rental	270
WOTSC	1,050
Total	$7,810

IV. Groundwater Studies

A. Install observation wells south of the Yellowstone River.

1. Location: Fort Union coal area south of the Yellowstone River including tracts nominated for coal leasing outside the Powder River structural basin.

2. Objectives: To extend the ground-water data base from which an assessment can be made of the resource, response to future stresses can be predicted, and pollution and supply problems can be detected and defined. To provide the ground-water data necessary to extend in space the results of reclamation studies and to relate site studies to regional studies.

3. Procedures:

   a. Case, complete, and evaluate test holes drilled for coal exploration by other agencies as observation wells and/or as sites to obtain aquifer transmissivity or storage coefficient.
   b. Collect water samples shortly after drilling and testing.
   c. Analyze water samples for parameters listed in Table 1. If necessary, drill, case, and test pump test holes in critical areas where information is needed to calibrate and test ground-water models.

d. Enter test holes into existing monitoring program.
e. Cooperate with BLM offices to insure data is obtained in critical areas and that data collected by other public and private organizations is checked for quality and included in this activity.
f. Coordinate Montana Bureau of Mines and Geology program with BLM and USGS needs.

4. Report Products: Data will be summarized in interpretative reports released in the Hydrologic Atlas and WRI, USGS series. Data will be stored in automated files for release upon request.

5. Relationship to Other Studies: Test hole data collected under this activity constitutes a link between site-specific studies and the studies necessary to describe and predict the regional effects of coal extraction on the ground-water resources.

6. Distribution of Funds:

Laboratory Services	1,700
Pump Testing and Rig Time for Installation of Casing	2,700
Purchase of Well Casing	2,700
Salaries for Field Operations	4,000
Travel	3,800
Salaries for Coordination Efforts	1,300
Data Processing	600
WOTSC	2,600
Total	$19,400

B. Install observation wells and collect ground-water data north of Yellowstone River.

1. Location: Fort Union coal area north of the Yellowstone and South of the Missouri Rivers including parts of Garfield, McCone, Richland, and Prairie Counties and Bull Mountains Basin.

2. Objectives: Many tracts of land between the Missouri and Yellowstone Rivers have been recently nominated for coal leasing. Although the long-term objectives are the same for this activity as for activity IV-A, the data base for the area is much smaller and the short-term objectives are directed toward acquiring data that defines the quantity and quality of ground-water throughout the area.

3. Procedures:

   a. Case and test holes drilled by other agencies.
   b. Collect and analyze water samples.
   c. Establish an observation well network from existing wells and newly drilled test holes.
   d. Make water-level measurements and operate water-level recorders near streamflow stations.
   e. Conduct low-flow study of streams in Bull Mountain Basin.

4. Report Products: The data and its interpretation will be used in reports that assess the ground water resource and the possible hydrologic effects of coal extraction. Data will be stored in WRD automated files before its interpretation and release in the WRI series.

5. Relationship to Other USGS Studies: This activity obtains ground-water data near streamflow stations operated under parts of the EMRIA program.

6. Distribution of Funds:

Laboratory Services	6,000
Pump Testing, and Rig Time for Installation of Casing	4,900
Salaries for Field Operations	7,230
Travel	4,000
Data Porcessing	1,500
WOTSC	3,690
Total	$27,320

C. Ground Water Monitoring

1. Location: Bear Creek, Otter Creek, East Fork Trail Creek, and observation wells previously installed south of the Yellowstone River.

2. Objectives: To provide a ground-water data base from which an assessment can be made of the resource, future responses to stresses can be predicted, and pollution and supply problems can be detected and defined. The data also are necessary to extend in space and time the results of the reclamation site studies and to relate the results of other ongoing programs to the site studies.

3. Procedures:

a. Pump and collect water samples from test holes drilled in previous fiscal years.
b. Analyze water samples.
c. Make water-level measurements and continue operation of water-level recorders.
d. Compile and analyze data.

4. Report Products: The data and its interpretation will be used in reports that assess the possible hydrologic effects of coal extractions and predict the hydrologic effects of mining and related activities.

5. Relationship to Other USGS Studies: Data collected under this activity will be used to help define pre-mining conditions at reclamation study sites, help calibrate ground-water models to predict the effects of mining, and help transfer data to surrounding areas from intensively studied reclamation sites.

6. Distribution of Funds:

Laboratory Services	15,000
Salaries for Field Operations	6,800
Travel	3,500
Data Processing	1,000
Data Compilation and Analyses	13,500
WOTSC	6,200
Total	$46,000

V. Lease Tract Site Investigation:

A. Location: High priority lease areas in Fort Union Coal Region, eastern Montana.

B. Objectives: Provide the data and interpretations necessary to predict and suggest alternate solutions to the water problems that may be important during mining and reclamation. Detailed site-specific studies of several lease areas including Otter Creek, Bear Creek, Pumpkin Creek, and East Trail Creek have and will provide information on water resources of individual sites. This study will expand on these site-specific investigations to provide a common level of interpretation for the remaining high-priority lease areas.

C. Procedures: A matrix showing the present level of knowledge of hydrologic conditions for high-priority lease areas will be constructed to identify areas and kinds of information where further work is necessary. The matrix will serve as a guide to plan data collection programs needed to define hydrologic conditions. Water-level monitoring, water-quality sampling, geologic mapping, and stream gaging may be required in some areas. Ongoing data collection activities will continue for the previous site-specific studies to provide longer term data on water-level fluctuations, variability of streamflow, and variations in water quality.

D. Report Products: Information from this study will be used in the preparation of Environmental Assessment Reports for about 10 high-priority lease areas. BLM must have the EAR's completed by September 1978 and will need the information beginning about July 1978 to meet their schedule. The information will be provided in a form useable for inclusion in the EAR's.

E. Distribution of Funds:

Salaries for Data Collection	43,000
Travel	6,000
Laboratory Services	7,000
Data Processing	6,000
Data Interpretation and Reduction	15,400
Space Rental	3,200
WOTSC	12,600
Total	$93,200

VI. Geohydrologic Mapping

A. Location: Bull Mountain Basin and Fort Union coal region north of Yellowstone River and south of Missouri River.

B. Objectives: Geohydrologic maps have been prepared for part of the Fort Union Coal Region at a scale of 1:500,000. This project covers the remaining area of the Fort Union Coal Region. The completed maps will provide a basis for further hydrologic work and are prerequisite to modeling work anticipated in the near future.

C. Procedure: Available geologic mapping will be compiled and field checked. Aerial photos and field mapping techniques will be used to identify major aquifer units within the Tertiary and Quaternary deposits. Field work will be minimized as much as possible to expedite the work.

D. Report Products: Final report will be a series of maps covering the study area at a scale of 1:500,000. The maps will be published in the USGS Miscellaneous Investigations Map series.

E. Relationship to Other USGS Studies: This program compliments previous mapping done in the Powder River Basin of the Fort Union Coal Region. The completed maps will be indispensable in identifying aquifer units penetrated by wells, providing a basis for modeling the ground-water flow systems, and defining the shallow geologic framework of the Fort Union Coal Region. The maps will be particularly useful in preparation of EAR's for high-priority lease areas by providing information on the geologic setting and distribution of aquifer units present.

F. Distribution of Funds:

Salaries	17,300
Travel	3,000
Preparation of Base Maps	2,000
Preparation of Final Maps	15,000
Space Rental	1,600
WOTSC	6,100
Total	$45,000

VII. Evaluation and Redesign of WQ and SW Networks

A. Location: The proposed work covers the Fort Union Coal Region south of the Yellowstone River.

B. Objectives: Numerous stream gaging and water-quality data collection sites have been installed and operated in the southern part of the Fort Union Coal Region to obtain basic data needed in evaluating effects of mining. Anaysis of the data collected during the past 3 years is needed to define geochemical processes, determine relationships, and evaluate necessity of modifying the network.

C. Procedure: Statistical methods will be used to analyze and evaluate the data. Regression techniques will be applied to determine station correlations. Data collected on sites will be evaluated to determine desirability of continuing, modifying, eliminating, or replacing stations to insure that monitoring sites provide the maximum amount of needed information at a minimum cost.

D. Report Products: The results of this investigation will be used to modify the existing surface water quality monitoring network in the southern part of the Fort Union Coal Region. A final report summarizing the statistical correlations and regressions will be completed by September 1978. The report will be released in the Water Resources Investigation series for distribution to BLM and other WRD districts.

E. Distribution of Funds:

Salaries	24,000
Space Rental	1,420
Computer Costs	4,800
Report Preparation	5,000
WOTSC	5,500
Total	$40,720

VIII. Develop Isopluvial Map for Southeastern Montana

A. Objective: To develop an isopluvial map for southeastern Montana that will permit estimates of water yields from ungaged watersheds.

B. Approach: Use all existing available rainfall-runoff data in the area to develop the map.

C. Report: An isopluvial map of southeastern Montana.

D. Distribution of Funds:

Salaries	15,770
District Overhead	760
WOTSC	2,470
Total	19,000

IX. Grants

A. Grant to Montana Bureau of Mines and Geology for test drilling, test pumping, and well inventories in areas where coal leasing appears imminent.

1. Location: Fort Union coal area south of the Yellowstone River and Bull Mountain Basin.

2. Objectives: To provide a ground-water data base from which an assessment can be made of the resource, future response to stress predicted, and pollution and supply problems detected and defined. Also, to provide a test drilling program that can be directed by the USGS and BLM to areas where ground-water information is needed most due to impending leasing or due to critical needs for hydrologic information.

3. Procedures:

   a. Drill and log test holes to about 50 feet below the lowest "strippable" coal bed.

b. Case with 4-inch plastic casing, perforate, and isolate the aquifer being investigated from the rest of the rock section.
c. Pump test the aquifer and collect water samples for laboratory analysis.
d. Inventory wells in specific areas such as Bull Mountain Basin.
e. Compile data to submit to USGS.

4. Report Products: Field data will be compiled in a report describing the results of the grant and 20 copies submitted to the USGS, who will send copies to the BLM.

5. Relationship to Other USGS Studies: This program supplements USGS data collection activities and provides test drilling at high-priority lease sites where subsurface data is needed to define ground-water systems.

6. Distribution of Funds:

Grant to Montana Bureau of Mines and Geology	60,010
District Costs for Review	2,530
WOTSC	9,760
Total	$72,300

B. Grant to Montana Department of Health and Environmental Science-- Biological-Benthic Study of Streams Draining Coal Fields in Southeastern Montana and Relationships to Salinity

1. Location: Fort Union Coal region in southeastern Montana.

2. Objectives: The objectives of this proposal are to obtain biological data on periphytic and macroinvertebrate components of stream benthos at selected sites in the southern part of the Fort Union Coal Region and assess the effects of salinity on stream biota. The study hopefully can provide information on potential effects of increased salinity resulting from mining activities on stream biota.

3. Procedures: Biological sampling will be directed to perennial or near perennial streams now being monitored by the USGS for water quality information. Intensive biological sampling will be done on two to four streams at four to six locations for two years. Seasonal sampling will also be done at ten to fourteen sites. The effects of salinity in the biota will be evaluated.

4. Report Plans: The contractor will provide interim reports on the study and a final report at the end of the two-year investigation.

5. Relationship to Other USGS Studies: The USGS is collecting considerable information on quality of water in streams in the Fort Union Coal Region. Relating this data to biological productivity is important in evaluating potential environmental impacts of mining activities.

6. Distribution of Funds:

Grant	19,400
District Costs for Review	1,360
WOTSC	3,240
Total	$24,000

C. Grant to Montana State University--Sulpher Cycle Study

1. Location: Laboratory and selected mine locations in Fort Union Coal Region.

2. Objectives: Sulfate concentrations in ground waters in the Fort Union Coal Region are relatively high. Sulfate reduction has been observed but the mechanism is poorly understood. The purpose of this study is to determine what role bacteria play in the sulfur cycle.

3. Procedures: The investigation will proceed along three lines of study:

   a. The technique of isotope fractionation will be used to determine whether the sulfide in ground water is bacterially produced.
   b. Attempts will be made to detect sulfate producing bacteria in ground water samples and abundance of these organisms will be quantified.
   c. Rates of dissimalatory sulfate reduction will be measured using sensitive radioactive isotopic methods.

4. Report Plans: The contractor will provide a final report at the completion of the investigation.

5. Relationship to Other USGS Studies: The USGS is actively engaged in geochemical studies in the Fort Union Coal Region as a tool for understanding the ground-water flow systems. An important aspect of the ground water quality is the mechanism of the poorly understood sulfur cycle. This research will provide valuable information regarding this complex problem and will aid in interpreting the overall geochemical processes associated with mining activities.

6. Distribution of Costs:

Grant	13,160
District Costs for Review	1,540
WOTSC	2,300
Total	$17,000

X. Other Studies (MT-930-4340-5273)

A. Big Sheep Creek

1. Data Collection:

   a. Continuous flow.
   b. Four months daily suspended sediment data collection.

B. Reservoir Survey:

1. Location: North Valley recreation area, the following reservoirs:

   VR-9, Air Base Ponds NE 1/4 13, T31N, R39E (2 ponds).
   VR-61, Langen Reservoir NW 1/4 26, T33N, R38E.
   VR-82, SW 1/4 28, T34N, R39E.
   Unnamed, NE 1/4 35, T37N, R38E.
   Unnamed, NW 1/4 11, T36N, R38E.
   Unnamed, SE 1/4 27, T36N, R36E.
   Unnamed, NW 1/4 9, T35N, R36E.
   Unnamed, SW 1/4 33, T35N, R37E.
   Gay, SW 1/4 2, T33N, R37E.
   VR-64, NW 1/4 13, T33N, R37E.
   Hose, SE 1/4 17, T33N, R37E.
   Unnamed, NW 1/4 35, T34N, R37E.

2. Approach: Twelve reservoirs in the North Valley Recreation Area will be sampled in fiscal year 1978. The following sampling periods were chosen to study each reservoir when limnological conditions are most critical to the proposed reservoir uses:

   a. Late winter, when ice cover prevents exchange of gases with the atmosphere.
   b. Early spring, when ice cover is gone, the reservoirs are completely mixed, and peak inflow has occurred.
   c. Late summer, when there is a possibility of stratification of the reservoir water and development of anoxic conditions in the hypolimnion.
   d. After fall mixing when any stratification has been disrupted and hypolimnion water is mixed throughout the lake, possibly causing less desirable habitat for biota.

The U.S. Geological Survey, Central Region, will provide guidance for the Bureau of Land Management in describing the morphology of each reservoir, constructing a bench mark for reservoir capacity calculations, and estimating the annual sediment yield of each watershed and remaining reservoir life.

Measurements of light penetration will be made at each reservoir during each visit as an indication of the relative amount of suspended material in each reservoir. Depth profiles of each reservoir will be made for temperature, dissolved oxygen, specific conductance, and pH.

To further characterize each reservoir, the concentrations of selected chemical constituents will be determined. Chemical analyses will include: (1) major dissolved constituents -- calcium, magnesium, potassium, sodium, bicarbonate, chloride, fluoride, silica, and sulfate; (2) trace elements (dissolved) of primary concern in the area -- boron, copper, iron, lead, manganese, and zinc; (3) trace elements of secondary concern -- arsenic, barium, cadmium, chromium, cobalt, mercury, nickel, selenium, silver, and vanadium; and (4) plant nutrients -- dissolved ortho phosphate, dissolved phosphorus, total phosphorus, dissolved organic carbon and suspended organic carbon.

Phytoplankton, benthic invertebrate, and bacterial samples will be collected and analyzed from each reservoir to reflect the quality of life each reservoir is supporting.

Field measurements for dissolved oxygen, temperature, specific conductance, and pH will be made at one meter intervals using a Martek water-quality instrument near the outlet or middle of each reservoir (the deepest site). Light penetration at each sampling site will be measured using an 8-inch (20 cm) diameter Sacchi Disk.

Water samples for chemical analysis will be collected near the bottom and surface of each reservoir site using a Kemmerer water sampler. The samples will be field treated for preservation. Field parameters will be determined at the site and laboratory samples will be analyzed at an accredited laboratory.

Phytoplankton will be collected from each reservoir using a plankton net with a .202 mm mesh opening. Samples will be collected by towing the plankton net vertically the full depth of water at each site. Benthic invertebrate samples will be collected with an Ekman grab at three locations near the outlet of each reservoir. Phytoplankton and benthic invertebrates will be analyzed at a private laboratory. Procedures for the preservation and analysis (identification and enumeration) of phytoplankton and benthic invertebrates will follow methods described by Slack and others (1973).

Total coliform, fecal coliform, and fecal streptococcus bacteria will be collected from grab samples of water at each chemical sampling site and near the shore of easiest access to each reservoir. Field analysis of bacterial samples will follow techniques described by Slack and others (1973).

Field work for the proposed study of reservoirs in North Valley area will begin the winter of FY 78. Samples will be collected by personnel from the USGS Fort Peck Field Office with assistance from district office personnel. The project chief will devote about six man weeks of effort during FY 78 an about 1/3 man year in FY 79. He will be supported by field personnel from the Fort Peck field office and the district office.

3. Reports: The final report will be available for review early in 1979 and in final form before the end of FY 79.

The report will include a data summary and an interpretative section dealing with factors that might limit some of the stated objectives. The report will be published as a Water-Resources Investigation.

D. Distribution of Funds:

Salary	
Data Collection	4,350
Data Analysis	1,850
Lab Charges	9,000
Travel	3,000
Stream Gage	5,840
Space Rental	910
District Support	3,380
WOTSC	3,510
Total	$31,840

MONTANA

LIST OF WATER QUALITY PARAMETERS

Parameters for Chemical Analysis in Ground Water

Common Constituents

- Silica, dissolved
- Iron, dissolved
- Calcium, dissolved
- Magnesium, dissolved
- Sodium, dissolved
- Potassium, dissolved
- Bicarbonate
- Sulfate, dissolved
- Chloride, dissolved
- Fluoride, dissolved
- Nitrate & nitrate total as N
- Dissolved solids
- Sodium absorption ratio (SAR)
- pH
- Specific conductance
- Alkalinity, total
- Temperature
- Color

Trace Elements, Nutrients and Radichemical

- Aluminum, dissolved
- Arsenic, dissolved
- Manganese, dissolved
- Barium, dissolved
- Cadmium, dissolved
- Cobalt, dissolved
- Chromium, dissolved
- Lead, dissolved
- Molybdenum, dissolved
- Nickel, dissolved
- Strontium, dissolved
- Vanadium, dissolved
- Zinc, dissolved
- Sulfide, dissolved
- Bromide
- Iodide
- Nitrogen, ammonia, total
- Nitrogen, total organic
- Nitrogen, total Kjeldahl
- Nitrogen, total
- Nitrogen, total as NO_3

- Phosphorus, total
- Carbon, total organic
- Arsenic, dissolved
- Boron, dissolved
- Copper, dissolved
- Mercury, dissolved
- Selenium, dissolved
- Gross alpha and beta dissolved and suspended

NEW MEXICO

I. Location of Study

Areas of study are located in San Juan County in northwestern New Mexico. The area near Fruitland, New Mexico is located within and around the San Juan Coal Mine lease (Sections 3, 4, 9, 10, 15, 16, 21, 22, 27, 28, 33, 34 of Township 30 North, Range 15 West). The area near the Bisti Trading Post is within and around BLM's Bisti West EMRIA reclamation study area (Sections 6, 7, 8, 17 of Township 23 North, Range 12 East). The area near the community of Kimbeto is within and around BLM's Kimbeto reclamation study area (Sections 6, 7, 17, 18, 19 of Township 22 North, Range 10 West). Other small watersheds will be selected from areas draining the strippable coal deposits in the general vicinity of the above locations.

II. Objectives and Procedures

The objectives of the program are to develop predictive models to aid the BLM in the management of coal-lease areas and rehabilitation of spoil piles in the areas mined for coal. Emphasis during the 1978 fiscal year will be on:

A. Refinement of data collection procedures at established sites to fit the modeling effort.

B. Collection of data to develop relation of streamflow, sediment transport, and water quality characteristics to selected basin parameters that can be measured or identified.

C. Investigating quantity and quality of the ground-water supply.

D. Compiling the water resources data that is available in the coal-lease areas.

E. Begin development of a rainfall-runoff model to describe the stream-flow characteristics for the coal-lease areas in northwestern New Mexico.

III. Hydrologic Modeling

A. Modification or addition of the following elements will be made to the basic data collection program to help calibrate surface flow basin models being developed for defining and predicting hydrologic processes in the coal lease areas.

1. Add digital punch recorders to the five streamgaging stations to automate data processing. To obtain a better definition of the runoff hydrograph during short duration summer runoff, a shorter punch interval of 5 minutes will be used during the storm period from mid-June to mid-October.

2. Install and operate continuous recording rain gages on the watersheds of Shumway Arroyo, De-Na-Zin Wash, Hunter Wash, and Ah-She-Sli-Pah Wash (4 sites) for modeling rainfall-runoff relationships. Non-recording rain gages will be maintained on the Ah-She-Sli-Pah Wash to study distribution of precipitation watershed. Ah-She-Sli-Pah Wash has been selected as the control basin for studying rainfall-runoff relationships.

3. Install and operate a continuous recording meteorologic station on the Ah-She-Sli-Pah watershed for measuring precipitation, air temperature, soil temperature, solar radiation, wind speed, wind direction, soil moisture and humidity. Any rainfall-runoff relationships derived with these meteorologic factors would be tested on other watersheds.

4. Modify the single-stage sampling configuration at Ah-She-Sli-Pah Wash, Shumway Arroyo, and De-Na-Zin Wash streamgaging stations to obtain nine samples for each flow event. Three samples will be collected at each of the three stages. This will provide enough values to statistically evaluate the water quality data being collected by this technique.

B. Reports:

1. Process and store the data collected for the rainfall-runoff model in the WATSTORE system.

2. Begin the development of a rainfall-runoff model for the San Juan Basin.

C. Distribution of Funds:

Item	Cost*
1	3,000
2	7,000
3	20,000
4	15,900
Total	$45,900

IV. Reconnaissance Studies

A. The data to develop a relation to estimate streamflow, sediment transport, and water quality characteristics from basin parameters that can be measured or identified will be collected during the 1978 fiscal year. The data to be collected for each of 20 small watersheds of less than 10 square miles includes channel-geometry measurements, streambed material, particle size distribution, channel slope, infiltration rate of watershed and vegetation cover. Single stage samples will be installed and operated for one year to collect samples for determining suspended sediment and chemical quality of water on the 20 watersheds. The sediment data will be supplemented with pond-sedimentation data if this data is available. Other data that will be compiled for each of the watersheds above includes drainage area, mean-annual precipitation, watershed slope, and basin shape. Of the 20 small watersheds, 15 sites will be on undisturbed watersheds in and adjacent to the coal-lease areas and five sites will be on spoil-piles and reclaimed areas. The relation of the streamflow, sediment transport, and water quality characteristics to the basin parameters (to be collected or compiled) will be presented in an interpretive report at the end of two years.

B. Drill and case three holes for water observation wells in the proposed Ojo Encino EMRIA study area. Wells will be completed in the 1) overburden, 2) coal zone, and 3) Pictured Cliffs Formation. A set of samples will be collected and analyzed annually.

C. Pump test the 10 water observation wells in the Kimbeto study area to obtain aquifer characteristic in the overburden, in the coal zone, and in the Pictured Cliffs Formation immediately below the coal.

D. Test holes will be drilled penetrating the entire thickness of the alluvium along the Chaco Wash to define the thickness of alluvium, water quantity, water quality, and hydrologic characteristics of the alluvium and the rate of movement of water through the deep and shallow parts of the alluvium.

E. Reports Products:

1. The U.S. Geological Survey's Water Resources Division has conducted hydrologic investigations for BLM's EMRIA program in northwestern New Mexico's coal-lease areas since 1974. A large part of the effort to date has been directed toward data collection so that base conditions of the surface and ground-water resources can be established. Initially, basic data collection was necessary because water resources information in the coal-lease areas was sparse. During the 1978 fiscal year, the basic data collected for the EMRIA program and related coal hydrology programs in New Mexico will be compiled into a single report along with statistical summaries of the data.

2. The hydrologic section for the Bureau of Land Management's EMRIA report for the Kimbeto Study Site will be completed during fiscal year 1978.

3. The interpretative report using basin parameters that can be measured or identified for estimating streamflow, sediment transport, and water quality characteristics is planned for completion during fiscal year 1979.

4. Any preliminary data will be furnished to BLM on a schedule agreed upon or when requested by BLM. Basic data tables of stream discharge, suspended sediment concentration, chemical analyses of surface and ground water, and ground water levels will be published in the annual basic data reports of the U.S. Geological Survey.

F. Distribution of Funds:

Item		Cost*
A		50,000
B		10,000
C		5,000
D		20,000
	Total	$85,000

V. Operation and Maintenance

A. A major part of the basic data collection program on the San Juan Coal Mine lease near Fruitland, the Bisti West study area, and the Kimbeto study area will be continued.

1. Maintain and operate the continuous recording stream-gaging stations on Shumway Arroyo (2 sites), Hunter Wash, De-Na-Zin Wash, and Ah-She-Sli-Pah Wash.

2. Maintain and operate the automatic pump sampler for suspended sediment and chemical quality sampling on Shumway Arroyo, De-Na-Zin Wash, and Ah-She-Sli-Pah Wash during the storm season from about mid-June to mid-October.

3. Continue chemical quality analyses of samples collected of flow events by either field observers, single stage samplers, or automatic pump samplers on the Shumway Arroyo system (4 sites), Hunger Wash system (2 sites), De-Na-Zin Wash system (5 sites), and Ah-She-Sli-Pah Wash (4 sites).

4. Continue suspended sediment sampling of flow events by either field observers, single stage samplers, or automatic pump samplers at the sites under item III. samples will be analyzed for concentration and particle size distribution.

5. Continue annual water level measurement and sampling at the ground-water observation wells on the San Juan Coal Mine lease (5 sites), Bisti West study area (7 sites), and Kimbeto study area (10 sites). Analyses of water samples will be made to determine chemical constituents.

B. Report Products:

1. The U.S. Geological Survey's Water Resources Division has conducted hydrologic investigations for BLM's EMRIA program in northwestern New Mexico's coal-lease areas since 1974. A large part of the effort to date has been directed toward data collection so that base conditions of the surface and ground-water resources can be established. Initially, basic data collection was necessary because water resources information in the coal-lease areas was sparse. During the 1978 fiscal year, the basic data collected for the EMRIA program and related coal hydrology programs in New Mexico will be compiled into a single report along with statistical summaries of the data.

2. The hydrologic section for the Bureau of Land Management's EMRIA report for the Kimbeto Study Site will be completed during fiscal year 1978.

3. The interpretative report using basin parameters that can be measured or identified for estimating streamflow, sediment transport, and water quality characteristics is planned for completion during fiscal year 1979.

4. Any preliminary data will be furnished to BLM on a schedule agreed upon or when requested by BLM. Basic data tables of stream discharge, suspended sediment concentation, chemical analyses of surface and ground water, and ground water levels will be published in the annual basic data reports of the U.S. Geological Survey.

C. Distribution of Funds:

Item		Cost*
1		18,000
2		4,500
3		25,000
4		18,000
5		14,300
	Total	$79,800

* Costs are all inclusive (salaries, travel, supplies, WOTSC, etc.).

NEW MEXICO

LIST OF WATER QUALITY PARAMETERS

The water quality parameters that may be measured on water and soil samples collected for this study are listed below. The project investigator shall select the parameters to be measured for a sample and the frequency of measurement at a site. Other parameters may be added to this list if needed. The dissolved and suspended concentrations of many constituents, particularly trace elements, will be determined.

Acidity
Alkalinity
Aluminum
Arsenic
Barium
Beryllium
Bicarbonate
Boron
Cadmium
Calcium
Carbon, organic
Carbonate
Chemical oxygen demand
Chloride
Chlorophyll
Chromium
Cobalt
Coliform bacteria, fecal
Color
Copper
Cyanide
Fluoride
Hardness
Hydroxide
Iron
Lead
Lithium
Magnesium
Manganese
Mercury
Molybdenum
Nickel
Nitrogen, ammonia
Nitrogen, nitrate
Nitrogen, nitrite
Oxygen, dissolved
pH
Phosphorous, as dissolved PO_4
Phosphorous, total
Potassium
Residue at 180 C (dissolved solids)
Selenium
Silica
Silver
Sodium
Specific conductance
Streptococci bacteria, fecal
Strontium
Sulfate
Sulfide
Temperature, water
Turbidity
Zinc
Phytoplankton
Radioactivity, gross alpha
Radioactivity, gross beta
Radium
Uranium
Suspended sediment
Suspended sediment particle size
Discharge, streamflow or yield

NORTH DAKOTA

I. Hydrologic Modeling

A. Beulah Trench

1. Objectives: Preliminary data indicate that the proposed expansion of strip-mining activities in the Beulah Trench area, North Dakota, may result in changes in the streamflow, geochemical, and ground-water regimen. Some changes will be temporary but others may remain even after strip mining has ceased. The purpose of this investigation is to (1) determine pre-mining hydrologic and geochemical conditions in a small representative drainage basin, (2) provide historical data with which to compare the magnitude of change with mining, and (3) determine the hydrologic and geochemical effects of mining in nearby areas on the Antelope Creek aquifer.

   In order to understand the operation of the existing hydrologic and geochemical systems in the Beulah Trench area and predict the effects of new stresses imposed on it by mining operations, it will be necessary to simulate the system by means of a digital model or models involving finite element and difference approximations of the ground-water and surface-water flow and mass transport equations. Although either electric analog or digital model could be used, the digital model is preferable because of time, cost, and facility restrictions. A three-phased approach to quantitative hydrology in the study area is planned.

   a. Phase I: (Partially completed in 1977 Fiscal Year).

      (1) Collation and evaluation of existing hydrologic and chemical data that will be used as the resource base.
      (2) Development of conceptual models of the hydrologic and geochemical systems and selection of digital computer models that simulate the conceptual models.
      (3) Output from the digital models will aid in the selection of locations of needed test holes, observation wells, and other data acquisition sites.
      (4) Adjustment and refinement of conceptual and digital models, as necessary.

   b. Phase II: (Partially completed in 1977 Fiscal Year).

      (1) Collection of new geologic, hydrologic, and chemical data.
      (2) Refinement of data for the digital models and evaluation of results. Readjustment and

calibration of digital models, as necessary.

(3) Selection of additional data collection sites based upon output from models.

(4) Digital models representing the present hydrologic and geochemical systems will be available at the end of Phase II.

c. Phase III:

Based on the conceptual and digital models developed by the end of Phase II, the effects of mining on various phases of the hydrologic and geochemical systems will be forecast. A final, complete report is planned for September 30, 1979.

2. Relationship to Other Closely Associated Non-EMRIA Funded Activities:

The Beulah Trench lignite deposit is one of the deposits that will be covered by the hydrologic reconnaissance studies under ND-070F, which was started in FY 75 and is funded by the U.S. Geological Survey. The data collection under ND-070F will be of value to the present study. Inasmuch as the ultimate objective of ND-070F is to provide an in-depth appraisal of the hydrologic effects of mining for each of the identified strippable deposits, the Beulah Trench study will result in a savings in the eventual overall cost of ND-070F.

Data on streamflow, sediment loads, quality of water, and ground-water levels are being collected in the vicinity of the study. These data are being collected through programs with the North Dakota State Water Commission, the Environmental Protection Agency, and Corps of Engineers, and the U.S. Geological Survey funds. There will be a mutually beneficial exchange of data between the programs.

3. Distribution of Funds:

Salaries	34,040
Travel	7,730
Contractual Services	15,000
Supplies and Equipment	27,950
Laboratory Costs	6,000
Data Processing, including Computer Costs	2,000
Administrative Costs (17%)	18,530
Total	$111,250

B. Wibaux-Beach

1. Objectives: The strippable lignite of the Wibaux-Beach deposit is a major aquifer of the area and is in close stratigraphic association with the other aquifers. The deposit area is probably within a region of major recharge to the lower Tongue River and Ludlow aquifers. The probable hydrologic impacts of coal development on these aquifers are not known. Most streams within the study are ephemeral, but one does flow for most of the year and is the source of irrigation water for several adjacent landowners. Mining activities may impact the surface waters in terms of both quantity and quality of stream flow. Also of concern are the geochemical modifications attendant the mining process and the effects these alterations may impose on the hydrologic system.

   The objectives of this investigation are to (1) To define the pre-mining hydrology and geochemical regime within the drainage basins containing the Dickinson lignite deposit. In so doing, a historical data base will be established with which to assess any modifications attendant on future coal mining. (2) To develop the capability of projecting the hydrologic ramifications of various land treatments imposed by the mining process.

   Strip mining disrupts the zone of interaction between the atmospheric, terrestrial, and subterranean segments of the hydrologic cycle. Programs and instrumentation necessary to determine the flow and quality characteristics and the various modes of exchange of water between the respective segments will be initiated early in the project. The data collected will be used in conjunction with digital models to gain a thorough knowledge of the hydrologic regime. Quantitative hydrologic parameters will be refined and data deficiencies will be identified with the aid of the models. When the models are calibrated and verified against the present hydrologic system, they will be available for estimating the hydrologic ramifications of various land treatments within the study area. A final complete report is planned for April 1980.

2. Relationship to Other Closely Associated Non-EMRIA Funded Activities:

   The study proposed herein will be funded jointly through EMRIA funds and U.S. Geological Survey Federal funds. The Wibaux-Beach lignite deposit is one of the deposits covered by the hydrologic reconnaissance studies under ND-070F, which was started in FY 75, is scheduled for completion in

FY 77, and is funded by the U.S. Geological Survey. The portion of the deposit in Golden Valley County is covered by the County Water Resources Study under ND-069, which was started in 75 and scheduled for completion in 78. This study is funded under a cooperative agreement by the U.S. Geological Survey, North Dakota State Water Commission, U.S. Park Service, and U.S. Forest Service. These studies though at a reconnaissance level, result in substantial savings in the present study.

Data on streamflow, sediment loads, quality of water, and ground-water levels are being collected in the vicinity of the study. These data are being collected through programs with the North Dakota State Water Commission, and with U.S. Geological Survey funds. There will be a mutually beneficial exchange of data between the programs.

3. Distribution of EMRIA Funds:

Salaries	20,320
Travel	5,700
Contractual Services	13,900
Supplies and Equipment	34,900
Laboratory Costs	2,700
Data Processing, including Computer Costs	500
Administrative Costs (17%)	15,980
TOTAL	94,000
Additional Funds from USGS	94,500

C. Reports: Basic records for surface-water quantity and surface-water quality stations will be published in the U.S. Geological Survey annual series "Water Resources Data for North Dakota" or as an appendix to an interpretive report. Basic records for ground-water levels and ground-water quality stations will be available to BLM and other interested parties and as an appendix to the interpretive report. The interpretive report on the hydrologic evaluation of strip mining and reclamation in the Beulah Trench area is scheduled for review by April 1979 and will probably be published in the Water Resources Investigation series of the U.S. Geological Survey. The hydrologic model will be developed in 2-3 years.

II. Hydrologic Effects of Strip Mining in the Gascoyne Area, Bowman County, North Dakota.

A. Location: Eastern Bowman County, southwestern North Dakota.

B. Objectives: Lignite has been strip mined in the Gascoyne area for several years. Generally, the production has averaged about 100,000 tons per year. However, production is being increased to about 3,000,000 tons per year in order to supply the fuel needs of an electricity-generated plant in eastern South Dakota. The lignite will be shipped to the plant by rail.

A preliminary reconnaissance study has indicated that the proposed large expansion of strip-mining activities will result in changes in the streamflow and ground-water regimen in the area (Northern Great Plains Resources Program--Water Work Group, 1974). Some changes will be temporary but others may remain even after strip mining has ceased. The purpose of this investigation is to identify, measure, and evaluate the changes.

In order to understand the operation of the existing hydrologic system and to predict the effects of new stresses imposed upon it, it will be necessary to simulate the system by means of a conceptual model or models involving finite element and difference approximations of the complex ground-water and surface-water flow equations. The entire project was scheduled for three years and will be completed in FY 78.

1. Phase I. (Essentially completed in 1976, transition quarter, and 1977).

    (a) Collation and evaluation of all existing hydrologic and chemical data that will be used as the resource base for preliminary digital models.
    (b) Selection of suitable models.
    (c) Output from models will supply information as to the locations of needed test holes, observation wells, and other data acquisition sites.
    (d) Adjustment of digital model program, as necessary.

2. Phase II. (Partially completed in 1976, transition quarter, and 1977).

    (a) Collection of new geologic, hydrologic, and chemical data, including test drilling and well construction.
    (b) Refinement of data for the digital model and evaluation of results. Readjustment and calibration of digital models, as necessary.
    (c) Selection of additional data collection sites based upon output from models.
    (d) Valid digital model representing present hydrologic and geochemical systems will be available at the end of Phase II.

3. Phase III.

Based on the conceptual model developed by the end of Phase II, the effects of mining on various phases of the hydrologic system will be forecast. The results of the investigation will be published in the Geological Survey report. An interim report is planned for open-file release prior to the availability of the final report.

C. Relationship to Other Closely Associated Non-EMRIA Funded Activities:

The Gascoyne lignite deposit is one of the deposits that will be covered by the hydrologic reconnaissance studies under ND-070F, which was started in FY 75 and is funded by the U.S. Geological Survey. The data collection under ND-070F will be coordinated with the needs of, and will be of value to, the present study. Inasmuch as the ultimate objective of ND-070F is to provide an in-depth appraisal of the hydrologic effects of mining for each of the identified strippable deposits, the Gascoyne study will result in a savings in the eventual overall cost of ND-070F.

D. Reports:

Basic records for surface-water and water-quality stations will be published annually by the U.S. Geological Survey in "Water Resources Data for North Dakota, Parts 1 and 2." Basic records for ground-water and water-quality stations will be submitted annually to BLM and other interested parties. An interpretive report on the hydrologic effects of strip mining in the Gascoyne area will be published after the three-year study is completed, probably either as a U.S. Geological Survey Professional Paper or Water Supply Paper with an interim open-file report.

E. Distribution of Funds:

Salaries	40,900
Travel	2,040
Data Processing, including Computer Costs	14,000
Administrative Costs (17%)	11,660
Total	$68,600

NORTH DAKOTA

LIST OF WATER QUALITY PARAMETERS

Monthly

Field	Discharge, ft^3/s	SW only
	Temperature, °C	
	pH	
	Specific Conductance	
	Dissolved Oxygen	SW only
	Oxygen, percent saturation (calculation)	
Laboratory	Alkalinity (tot as CaCO3)	
	Bicarbonate	
	Calcium, Diss	
	Chloride, Diss	
	Residue, Diss at 180°C	
	Residue, Calc Sum	
	Residue, Diss Ton/Aft	SW only
	Residue, Diss Ton/day	SW only
	Fluoride, Diss	
	Hardness, Noncarb	
	Hardness, Total	
	Magnesium, Diss	
	Potassium, Diss	
	Silica, Diss	
	SAR	
	Sodium, Diss	
	Sodium, Percent	
	Sulphate, Diss	
	Nitrogen Tot as N	SW only
	Nitrogen Tot as NO3	SW only
	Nitrogen Total JKD as N	SW only
	NO2 + NO3 as N Tot	SW only
	Nitrogen, NH4 as N Tot	SW only
	Nitrogen, Diss Org as N	
	Nitrogen, NH4 as N Diss	
	Nitrogen, Diss KJD	
	Phosphorous, Tot as P	SW only
	Phosphorous, Tot as PO4	SW only
	Phosphorous Tot Diss as P	
	Carbon, Diss Org	
	Carbon, Susp Org	SW only
	Susp. Sed Conc.	SW only

Quarterly

Susp. Sed.	Size Analysis	SW only
Bed Matl.	Size Analysis	SW only
	BOD, 5-day	SW only
	Aluminum	
	Arsenic	
	Barium	
	Boron	
	Bromide	(Ground Water only)
	Cadmium	
	Chromium	
	Copper	
	Iron	
	Lead	
	Lithium	
	Manganese	
	Mercury	
	Molybdenum	
	Selenium	
	Strontium	
	Zinc	

Annual Radio Chem

Analysis Schedule 473

Gross Alpha, Beta -- Dissolved
Gross Alpha, Beta -- Suspended
Radium 226 by Radon,
Uranium Fluorometric

NOTE: Ground-water samples will be taken annually.

OKLAHOMA

I. Hydrologic Modeling

A. Purpose and Scope: BLM is charged with the responsibility of assessing the probable water resource impacts and reclamation capabilities of any area under Federal jurisdiction in which surface mining for coal might occur. None of the studies so far underway in Oklahoma's coal fields specifically addresses the problem of predicting the effects on water resources of extracting coal by surface mining techniques. Therefore, a study by the Survey in cooperation with BLM is scheduled to begin in FY 1978. The purpose of this study is to collect and interpret sufficient hydrologic data to predict and assess the effects of surface mining for coal and subsequent reclamation efforts on the hydrologic characteristics of any given area.

Development, calibration, and verification of a watershed model is a useful approach in designing a project that gives as its product the prediction of future effects. The data required for such a modeling effort are sufficiently complex and expensive as to render modeling large areas unfeasible in terms of available money and manpower. Therefore, Oklahoma District's study will be concentrated in Coal Creek basin near the town of Lehigh in Coal County, Oklahoma.

B. Watershed Selection Criteria:

1. Drainage area less than 10 mi^2 - Coal Creek's basin is approximately 8 mi^2.

2. Perennial stream - Coal Creek does not meet this criterion, but it is doubtful if any stream in the eastern Oklahoma coal field with a drainage basin less than 10 mi^2 is perennial.

3. Area has a reasonable chance of being mined - Hartshorne Coal (about 4 feet thick) is present in the western portion of the Coal Creek basin, and, according to BLM personnel, the area has a high lease potential.

4. Area is accessible to manpower and equipment - The study area is about 130 miles from both Oklahoma City and Muskogee and about 150 miles from Tulsa.

5. Ground-water development in the basin - The town of Lehigh has six wells in the basin, and approximately ten houses within the basin use wells for their domestic supply.

6. Line power available - Power is available at the proposed streamflow gage site and in the vicinity of Lehigh's six wells.

7. Basin topography and land use relatively homogeneous - The basin consists mostly of pasture land with approximately 200 feet of relief on the western side. The area is underlain by McAlester Shale with several sandstone units as much as 100 feet thick. The soils report for Coal County (1974) indicates that the soils are thick and loamy.

8. In addition to meeting most of the above criteria, the town of Lehigh has a precipitation station for which a long-term record (approximately 25 years) is available. Also, the land on which Lehigh's wells are located may be available as a potential site for additional climatological data gathering.

C. Conceptual Framework of Hydrologic System: Coal Creek basin study area is relatively flat pasture land with a maximum relief of approximately 200 ft on the western side. Dense forest cover is present in the western, more hilly portion of the basin.

The climate of the area consists of hot humid summers with average high temperatures in the nineties, and cool winters with little frozen precipitation. Annual precipitation averages between 40 and 45 inches with heaviest rainfall occurring in the spring.

Soils of the basin fall into three major groups. The Bonham-Bates-Parsons association, present over most of the study area, consists of deep and moderately deep, nearly level to gently sloping, loamy soils that have a clayey and loamy subsoil over sandstone, shale, or loamy or clayey sediment. The Homa-Rock outcrop association, present only in the western, more hilly portion of the study area, consists of deep, moderately steep and steep loamy soils that have a clayey subsoil over shale or clay, and rock outcrops. The third major soil type, present in the central and western portions of the study area, is the Hartsells-Homa association. This soil association consists of moderately deep and deep, very gently sloping to sloping loamy soils that have a loamy or clayey subsoil over shale, clay, or sandstone.

Coal Creek basin is underlain by the Hartshorne Sandstone and the McAlester Formation of Pennsylvanian age. The basin lies on the western flank of the Lehigh syncline, and the rocks dip northeast at about 500 ft/mi. The structure is significant because wells downdip from the outcrop of water-bearing sandstone beds are artesian and some of them flow.

The Hartshorne Sandstone, which is about 500 ft thick, consists of a lower sandstone unit and an upper coal-bearing shale unit. Sandstone of the lower unit is mostly fine grained and massive but locally it is shaly or conglomeratic. The upper shale unit is a few feet to about 100 ft thick and includes the important lower Hartshorne coal (about 4 ft thick) that extends across the basin; this is the coal that will be mined.

The McAlester Formation consists mainly of micaceous shale but includes several persistent, ridge-forming sandstones that are lithologically similar to the Hartshorne. A thin, unmineable coal at the base of the McAlester may be locally significant in affecting the quality of ground water. A sandstone unit about 100 ft above the base of the McAlester is important because it apparently is the source of water to wells which supply the town of Lehigh a few miles to the northeast.

Coal Creek is an ephemeral stream with periods of no flow in the summer, corresponding to the relatively dry season and the period of heavy evapotranspiration loss. The fact that Coal Creek has periods of no flow, even though it is in an area of relatively high precipitation, indicates that the soils and water bearing rock formations within the study area are not highly transmissive. Flowing wells and springs in the study area indicate that Coal Creek gains flow from the ground water system most of the time.

During intense rainfall events, Coal Creek is subject to sudden stage changes. High-water marks and local residents indicate that rapid rises and declines in stream stage of ten feet or more are not uncommon. During these flashy events a large percentage of sediment and chemical constituent loads are yielded.

D. Data Requirements

1. Stream Water-Quality:

a. Stream inventory - In May 1977 a preliminary reconnaissance was made of Coal Creek and three of its tributaries within the study area, and field determinations of stream discharge, water temperature, pH, and specific conductance were obtained. At that time samples for laboratory determinations of dissolved iron, chloride, and sulfate were collected. Results of these analyses indicate relatively high iron concentrations, and thus, a potential for acid mine drainage. Further samples will be collected at the same sites and possibly at others for the analysis of dissolved iron, manganese, and aluminum to aid in the determination of acid mine drainage potential.

b. Stream water-quality constituents - residue on evaporation, bicarbonate, carbonate, hardness, phosphorus, and dissolved calcium, magnesium, sodium, potassium, chloride, sulfate, iron, manganese, silica, zinc, fluoride, boron, nitrogen, and organic carbon - Samples for analysis of these constituents will be collected from Coal Creek at its study area outlet 2 to 4 times yearly, associated with differing flow regimes, in order to classify water type, help identify potential problems, and relate major ions to specific conductance.

c. Specific conductance, pH, water temperature - These parameters will be monitored continuously in order to determine their relation to chemical constituent concentrations and stream discharge.

d. Minor elements - arsenic, cadmium, chromium, mercury, copper, lead, aluminum, and molybdenum - At least 40 samples for analysis of these dissolved constituents will be collected yearly from Coal Creek at its study area outlet with samples from both storm runoff and base-flow periods. This relatively high sample frequency is needed so that the data can be analyzed statistically. The above selection of constituents are considered to be the most likely to adversely affect the present and projected uses of the water, which are livestock watering, domestic supply, and fish production.

e. Suspended sediment concentration and load - In order to determine the quantity of sediment being washed into the system and to determine the relation between suspended sediment and stream discharge, approximately 400 samples per year will be collected from Coal Creek at its study area outlet and analyzed for suspended-sediment concentration. Most of these samples will be collected during storm events, but some will be collected to define base-flow concentrations and loading.

2. Surface-Water Flow Regime:

a. Continuous precipitation monitoring at 4 sites within the basin and continuous stream discharge monitoring at the basin outflow will allow development of the relation between precipitation and runoff.

b. Continuous stream discharge monitoring will allow computation of mean daily discharge and peak and low flow durations and frequencies.

3. Ground-Water Quality:

a. Well and spring inventory - During May 1977, seventeen wells and three springs within the study area were inventoried and field determinations of water level (or discharge rate for springs), pH, specific conductance, and water temperature were made. At the same time samples were collected for the analysis of dissolved iron, chloride, and sulfate. Similar to the stream analyses, relatively high iron concentrations were observed, indicating a potential for acid mine drainage. To aid in the determination of acid mine drainage potential, further samples will be collected for analysis of dissolved iron, manganese, and aluminum. Also, to aid in assessment of acid mine drainage potential, approximately 20 rock samples from outcroppings will be collected for chemical and mineralogic analysis.

b. Water-quality constituents - residue on evaporation, bicarbonate, carbonate, hardness, phosphorus, and dissolved calcium, magnesium, sodium, potassium, fluoride, chloride, sulfate, silica, iron, boron, manganese, zinc, nitrogen, arsenic, lead, mercury, copper, cadmium, chromium, aluminum, molybdenum, and organic carbon - Samples for analysis of these constituents will be collected from approximately 10 wells in order to classify water type and quantify those constituents that could adversely affect the present or anticipated uses of the water.

4. Ground-Water Aquifer Properties:

a. Geologic information on formations present (including coal beds) - Outcrop areas, subsurface configuration, and areal extent will be defined. Since the available geologic map is not sufficiently accurate nor detailed, the study area will be mapped in detail with particular attention paid to coaly zones and minor sandstone units. Joint patterns and any minor faults that may affect permeability will be mapped. Samples of sandstone will be collected for laboratory analysis of verticle and horizontal permeability. In addition, samples of sandstone, shale, and coal and the underlying and overlying beds will be collected for chemical analysis. In order to help identify geochemical anomalies, chemical analyses of representative flora will be made.

b. Water level data - In order to draw water-level contour maps, annual mass water-level measurements will be made. This activity will be in addition to the reconnaissance-level well inventory previously described. One problem encountered during the May 1977 well inventory that may hinder water-level contour map drawing is the fact that some of the wells are flowing.

c. Seepage measurements - These measurements will be made primarily to gain an understanding of the ground water-surface water relationships. Annually, seepage measurements will be made during both summer and winter base-flow periods to aid in determination of evapotranspiration.

d. Test drilling - Tentatively, five test holes will be drilled. These proposed test holes will be drilled through the Hartshorne Sandstone to approximately 1,000 ft depths at the western wells and approximately 1,500 ft depths at the eastern wells. Water samples for chemical analysis will be collected from each sand encountered.

e. Geophysical logging - At each test hole and at other wells in the study area where access is granted, the following geophysical logs will be obtained: resistivity, self-potential, calipher, gamma, and possibly others.

f. Aquifer tests and observation well construction - Each significant sandstone aquifer will be tested. Each of the test holes will be completed and used as observation wells. Multiple completion may be necessary depending on results obtained from test drilling. The number of aquifer tests and the number of additional observation wells necessary also will depend on the results of test drilling and other geologic information obtained.

5. Evapotranspiration:

a. Surface geology and predominant soil and vegetation types in basin.

b. Continuous monitoring of air temperature, relative humidity, wind velocity, and incoming short-wave, long-wave and net solar radiation.

c. Soil moisture - One representative site will be selected within each major soil type, and soil-moisture measurements will be made at approximately two-week intervals.

6. Ponds:

   a. Inventory - From available maps and by field reconnaissance the number, distribution, and ages of ponds in the Coal Creek basin will be determined.

   b. Field measurements - Approximately ten ponds within the basin will be selected for field determinations of specific conductance, pH, water temperature, and depth of sediments. The purpose for obtaining depth of sediments measurements is to ascertain an approximate basin sedimentation rate.

E. Reports: Each year daily stream discharges and water-quality data will be published in the Water Resources Data for Oklahoma annual report. In addition, a basic data report presenting all data collected will be prepared annually. This basic data report also will describe the work accomplishments of the preceding year and outline the plans for the coming year.

During the course of the project, several relatively short interpretive reports will be prepared, each describing different phases of work. Interpretive reports will be prepared for each of the following major work phases:

1. Geology.
2. Test drilling, geophysical logging, and aquifer tests.
3. Water quality.
4. Flow regime.

F. Distribution of Funds:

Salaries	41,120
Travel	2,000
Lab Support, Data Processing, etc.	10,000
WOTSC	10,880
Total	$64,000

II. Hydrologic Monitoring and Collection of Hydrologic Data on Coal Lease Areas in Eastern Oklahoma

A. Location:

1. Near Blocker - parts of T6 and 7N, R16 and 17E.

2. Near Rock Island - parts of T8N, R26 and 27E.

3. Near Spiro - parts of T8 and 9N, R24 and 25E.

B. Approach:

1. Blocker Area:

   a. Blue Creek - (1) operate and maintain discharge station; (2) collect water quality and sediment samples.

   b. Blue Creek tributary - (1) make monthly discharge measurement; (2) collect water quality and sediment samples.

   c. Mathuldy Creek - (1) operate and maintain crest-stage gage; (2) make monthly discharge measurement; (3) collect water quality and sediment samples.

   d. Rain gage - operate and maintain recording rain gage.

   e. Ground-water level recorder - Install and maintain water-level recorder in abandoned well near Blocker.

2. Rock Island Area:

   a. James Fork near Cameron - (1) maintain crest-stage gage; (2) make monthly discharge measurement; (3) collect water-quality and sediment samples.

   b. James Fork near Hackett, Arkansas - continue collection of water quality and sediment samples.

   c. Rain gage - install and maintain recording rain gage.

   d. Ground-water level recorder - install and maintain water-level recorder in abandoned well near Rock Island.

3. Spiro Area:

   a. Coal Creek - (1) maintain two crest-stage gages; (2) make monthly discharge measurements; (3) collect water-quality and sediment samples.

   b. Ground-water level recorder - install and maintain water-level recorder in Coal Creek basin.

   c. Rain gage - install and maintain recording rain gage in Coal Creek basin.

C. Report Products:

1. Stream discharge, water-quality, sediment, and ground-water level data will be published in annual reports.

2. An interpretive report describing the general hydrology is in preparation.

D. Distribution of Funds:

Salaries	9,600
Travel	600
Laboratory Services	11,000
Supplies and Equipment	3,000
Data Processing	4,630
WOTSC + Assessments	5,900
Total	$34,730

UTAH

I. Hydrologic Reconnaissance of the Book Cliffs-Wasatch Plateau

A. Location: All or parts of known coal fields in east-central Utah; total area about 4,000 square miles.

B. Objective: To obtain hydrologic (primarily ground-water) data from past and current coal-related drilling programs -- data that might otherwise be lost because of a lack of emphasis on or knowledge of hydrology. These data will help:

1. Define the areal extent of aquifers that may be affected by coal-mining and land subsidence.
2. Select wells for continuation and modification of the water-level monitoring program.
3. Select wells for a water-quality monitoring program.
4. Define and recommend areas for additional test-drilling and water-quality testing.

C. Approach: Data to fulfill the objectives will be obtained by:

1. Search of existing files.
2. Visits to drilling sites.
3. Inquiries to any organizations involved with past or current drilling programs.
4. Measurement of water levels, spring discharge, and water-quality parameters.
5. Assisting in aquifer tests by private companies or conducting our own tests.
6. Collection and analysis of water samples.

D. Reports: A basic-data report composed of all information collected during the study will be compiled by September 1978.

E. Distribution of Funds:

Salaries	20,992
Travel and Transportation	5,500
Laboratory Support	650
District Overhead	6,160
WOTSC	5,198
Total	$38,500

II. Hydrology of the Ferron Sandstone in Castle Valley and Effects of Strip Mining Near Emery, Utah

A. Location: Southern Castle Valley in east-central Utah, total area about 800 square miles.

B. Objectives:

1. Determine the effects of stripping the upper confining layers of shale from the Ferron Sandstone aquifer and mined dewatering on:

    a. Existing wells and springs.
    b. Base flow and quality of water in streams.
    c. Quality of water in the Ferron Sandstone.
    d. Rates and directions of leakage between the aquifer and its confining layers.

2. Determine the effects of erosion and leaching of stockpiled overburden on the sediment, water quality, and biologic characteristics of streams.
3. Determine recharge and discharge, aquifer characteristics, and the quantity and quality of water available from the Ferron Standstone throughout Castle Valley.

C. Approach: During FY 1978 will consist of:

1. Literature survey and file search for previous studies done and hydrologic data collected in and near the study area, and for studies in other areas which have relevant results.
2. Contacting coal and oil and gas companies and Federal and State agencies to obtain drilling and hydrologic data and to coordinate future work.
3. Inventory of wells and springs to determine current discharge from the Ferron Sandstone.
4. Setting up the data-collection network of stream-gaging stations, precipitation gages, and observation wells.
5. Begin to define the hydraulic properties and water quality of the Ferron Sandstone and its confining beds with drilling, aquifer tests, and sampling (primarily using data obtained by or in cooperation with private companies).
6. Begin to design a digital model of the Ferron Sandstone.
7. If funds permit, begin drilling or augering shallow holes in the Ferron Sandstone and overlying shale to obtain water-level, water-quality, and geologic data.

D. Reports: An interpretive report and a basic-data report will be prepared by September 1980.

E. Distribution of Funds (FY 1978):
(Salaries are included in individual items and total about $35,000).

Planning	6,000
Data Collection	19,425
Lab Support	5,000
Computer Services	3,000
Install 3 Gaging Stations	6,000
Test Drilling	12,000
Travel	6,000
Reports	2,500
District Overhead	13,600
WOTSC	11,475
Total	$85,000

III. Hydrologic Study of the Uinta Basin, Utah

A. Location: Southeastern Uinta Basin; about 2,400 square miles.

B. Objective: To collect streamflow data in 1978 fiscal year and continuing contingent upon annual appropriations.

C. Approach:

1. Operate streamflow gaging station at one site:

09306900	White River at mouth near Ouray, Utah, in SE1/4SE1/4NW1/4 Sec. 2, T9S, R20E, Uintah County, Lat. 40°03'54", Long. 109°38'06".

2. Collect daily sediment samples at the gaging site shown under item 1 and calculate daily suspended-sediment loads.

D. Reports: Information will be included in normal Basic-Data reports of the Utah District. BLM may request the data directly if needed.

E. Budget Distribution of Funds:

Salaries	4,220
Sediment Observer	2,080
Travel and Transportation	1,000
Supplies and Equipment	100
Laboratory Support	2,000
Data Processing and Reporting	500
SLUC	480
WOTSC	1,620
Total	$12,000

WYOMING

I. Hydrologic Monitoring in Energy Resource Areas of Wyoming

A. Powder River Basin:

1. Location: Powder River basin in northeastern Wyoming.

2. Objectives:

   a. Determination of runoff characteristics for watersheds in or near areas of extensive deposits of coal.
   b. Determination of the physical effects of coal mining and land reclamation on surface runoff and ground-water recharge.
   c. Determination of the chemical and biologic quality of surface water and sediment transport in streams.

3. Procedures:

   a. Operate the following stream gages:

	SW	CQ	Sed
Powder River at Arvada			X
Clear Creek near Arvada			X
Dry Fork Cheyenne River near Bill	X	X	X
Lance Creek near Spencer	X	X	X
Belle Fourche River below Rattlesnake Creek	X	X	X
Belle Fourche River above Dry Creek	X	X	X
Belle Fourche River below Moorcroft	X	X	X

   b. Analyze sediment samples from beds and walls of selected ephemeral stream channels for immediate information on transport characteristics of previously unsampled streams.

4. Report Products: Publish basic data in annual report of USGS. Use the data in the preparation of interpretive reports.

5. Distribution of Funds:

Salaries and Benefits	31,600
Travel and Transporation	4,500
Utilities and Storage	2,000
Minor Contractual Services	1,500
Supplies and Materials	3,000
Minor Equipment	1,000
Miscellaneous Expenses	190
Rent	1,850
WOTSC	7,120
Total	$52,760

B. Green River and Great Divide Basins:

1. Location: Green River and Great Divide basins of Wyoming.

2. Objectives:

a. Determination of runoff characteristics for watersheds in or near areas of extensive deposits of coal and oil shale.

b. Determination of the physical effects of coal mining, land reclamation, and in situ oil shale reporting on surface runoff and ground-water recharge.

c. Determination of the chemical and biologic quality of surface water and sediment transport in streams.

3. Procedures:

a. Operate the following stream gages:

	SW	CQ	Sed
Separation Creek at upper station		X	X
Separation Creek near Riner	X	X	X
Delaney Draw near Red Desert			X
Bitter Creek above Salt Wells Creek	X	X	X
Salt Wells Creek near South Baxter	X	X	X
Beans Spring Creek near South Baxter	X		
Gap Creek below Beans Spring Creek	X		
Dry Canyon near South Baxter	X	X	X
Salt Wells Creek near Salt Wells	X	X	X
Little Muddy Creek near Glencoe	X	X	X
Muddy Creek near Hampton	X	X	X
Vermillion Creek near Hiawatha	X	X	X

b. Analyze sediment samples from beds and walls of selected ephemeral stream channels for immediate information on transport characteristics of previously unsampled streams.

4. Report Products: Publish basic data in annual reports of USGS. Use the data in the preparation of interpretive reports funded by the USGS.

5. Distribution of Funds:

Salaries and Benefits	59,450
Travel and Transportation	10,370
Utilities and Storage	3,610
Minor Contractual Services	2,260
Supplies and Materials	5,980
Minor Equipment	3,380
Miscellaneous Expenses	450
Rent	3,610
WOTSC	13,910
Total	$103,020

C. Hanna Basin:

1. Location: Hanna Basin in south-central Wyoming.

2. Objectives:

a. Determination of runoff characteristics for watersheds in or near areas of extensive deposits of coal.
b. Determination of the physical effects of coal mining and land reclamation on surface runoff and ground-water recharge.
c. Determination of the chemical and biologic quality of surface and ground water and sediment transport in streams.

3. Procedures:

a. Operate the following stream gages:

	SW	CQ	Sed
Big Ditch near Coyote Springs	X	X	X
North Ditch near Coyote Springs	X	X	X
Hanna Draw near Hanna	X	X	X

b. Analyze sediment samples from beds and walls of selected ephemeral stream channels for immediate information on transport characteristics of previously unsampled streams.

4. Report Products: Analyze data and prepare progress reports as significant data become available. Publish basic data in annual reports of USGS. Use the data in the preparation of interpretive reports funded by the USGS.

5. Distribution of Funds:

Salaries and Benefits	13,790
Travel and Transportation	2,110
Utilities and Storage	740
Minor Contractual Services	460
Supplies and Materials	1,220
Minor Equipment	690
Miscellaneous Expenses	90
Rent	780
WOTSC	3,100
Total	$22,980

D. Other Basins:

1. Location: Big Horn and North Platte basins.

2. Objectives:

   a. Determination of runoff characteristics for watersheds in or near areas of extensive deposits of coal.
   b. Determination of the physical effects of land use on surface runoff and ground-water recharge.
   c. Determination of the chemical and biologic quality of surface and ground water, and sediment transport in streams.

3. Procedure:

   a. Operate 5 streamflow, 6 chemical quality, and 12 sediment stations in or near areas of present or projected surface mining in the Big Horn and North Platte basins.

4. Report Products: Publish basic data in annual reports of USGS. Use the data in the preparation of interpretive reports funded from other sources.

5. Distribution of Funds:

Salaries and Benefits	15,570
Travel and Transportation	2,390
Utilities and Storage	830
Minor Contractual Services	520
Supplies and Materials	1,380
Minor Equipment	780
Miscellaneous Expenses	100
Rent	880
WOTSC	3,500
Total	$25,950

II. Hydrologic Considerations in Evaluating the Reclamation Potential of Surface-Mined Lands in Wyoming

A. White Tail Butte Site:

1. Location: Northeastern part of Powder River Basin.

2. Objectives:

   a. Determination of runoff characteristics for the watersheds at and near the site.
   b. Determination of the quality of surface and ground water.
   c. Determination of aquifer properties and potentiometric surfaces for various aquifers.
   d. Interpretation of the interrelations of hydrologic parameters and the probable effects of coal mining in the area.

3. Procedure: Considerable data have been collected on rainfall, surface runoff, surface-water quality, and water levels in wells at the White Taile Butte site and the adjacent USGS model mine site. Some data have been collected on the chemical quality of ground water and more test wells are to be cleaned and sampled under a USGS contract.

   All existing data and the data yet to be collected will be analyzed to define the hydrologic system in the vicinity of the site. The rainfall-runoff data will be used to develop a surface-flow model of the area. Streamflow-water quality correlations will be made to define their present relationships and the probable effects of mining on both of these parameters. The ground-water data will be used to draw potentiometric contour maps for different stratigraphic units. Where possible aquifer test data will be used to determine transmissivity and storage for different stratigraphic units.

4. Report Procedures: A descriptive report on the hydrology of the site will be written. A report on the runoff model will be written, if the data are adequate for modeling. The ground-water data should be adequate for modeling the system by the end of FY 1978, but the model and report cannot be completed during FY 1978.

5. Distribution of Funds:

Salaries and Benefits	8,430
Travel and Transportation	1,290
Utilities and Storage	450
Minor Contractual Services	280
Supplies and Materials	740
Minor Equipment	420
Miscellaneous Expenses	60
Rent	480
WOTSC	1,900
Total	$14,050

B. Red Rim Site:

1. Location: Southern part of the Great Divide Basin.

2. Objectives:

   a. Determination of runoff characteristics for the watersheds at and near the site.
   b. Determination of the quality of surface and ground water.
   c. Determination of aquifer properties and potentiometric surface.
   d. Interpretation of the interrelations of hydrologic parameters and the probable effects of coal mining in the area.

3. Report Products: The new data will be utilized to prepare an update of the report previously submitted. This report will describe the hydrology of the site and the probable effects of coal mining in the area.

4. Distribution of Funds:

Salaries and Benefits	2,410
Travel and Transportation	360
Utilities and Storage	130
Minor Contractual Services	80
Supplies and Materials	210
Minor Equipment	120
Miscellaneous Expenses	20
Rent	140
WOTSC	540
Total	$4,010

C. Potter Mountain - Salt Wells Creek Site:

1. Location: Southern part of Green River basin.

2. Objectives:

   a. Determination of runoff characteristics for the watersheds at and near the site.
   b. Determination of the quality of surface and ground water.
   c. Determination of aquifer properties and potentiometric surface.
   d. Interpretation of the interrelations of hydrologic parameters and the probable effects of coal mining in the area.

3. Procedure: The USGS collected hydrologic data at and near the Potter Mountain site, before learning the site had been dropped from the list of EMRIA study sites. The data collected was continued under the FY 1977 EMRIA program, and now enough data are available for some useful interpretations to be made.

4. Report Products: A descriptive report on the hydrology at the site will be written, including the probable effects of coal mining in the area.

5. Distribution of Funds:

Salaries and Benefits	4,820
Travel and Transportation	740
Utilities and Storage	260
Minor Contractual Services	160
Supplies and Materials	420
Minor Equipment	240
Miscellaneous Expenses	30
Rent	270
WOTSC	1,080
Total	$8,020

III. Drilling and Casing of Observation Wells

A. Location: Statewide in coal and oil shale areas.

B. Objectives:

1. Obtain monitoring wells in areas where data on ground water are needed to fill gaps.

C. Procedure:

1. Drill and case observation wells in areas where additional ground-water data are needed.

2. Purchase casing and pay for rig time to case test holes drilled by others in areas where ground-water data are needed.

D. Report Products: Chemical-quality and water-land data will be published in annual reports of the USGS. The data will be used in interpretive reports funded by the USGS.

E. Distribution of Funds:

Salaries and Benefits	2,410
Travel and Transportation	370
Utilities and Storage	130
Contractual Services and Casing	16,060
Supplies and Materials	210
Minor Equipment	120
Miscellaneous Expenses	20
Rent	140
WOTSC	540
Total	$20,000

IV. Water Quality Sampling Proposal for FY 1978 -- Green River Basin

A. Objectives: Collect data necessary to:

1. Identify streams with significant dissolved-solids loads.

2. Identify areas of significant salt yield.

    a. Classify salt yields of component drainage areas.
    b. Locate and determine discharge and dissolved-solids concentrations of springs and flowing wells.
    c. Determine variations in chemical quality due to irrigation, grazing, timbering, etc.

B. Background: The U.S. Geological Survey is presently conducting a water-resource study of the Green River Basin. Members of the project team have been studying the water resources of the area for about the past two years. Results of their preliminary investigations and planning are contained in U.S. Geological Survey open-file report 76-349, "A plan for study of water and its relation to economic development in the Green River and Great Divide Basins in Wyoming," by H. W. Lowham and others.

The Green River Project Team is familiar with the area and its available data. They have found an extreme shortage of water data for the plains areas, which include most of the BLM lands.

Since the Green River Project was started, several intensive sampling programs have been conducted. One intensive sampling program was conducted during April 1975, and another during October and November 1976. These programs were in cooperation with BLM, to aid in preparation of environmental impact statements. Sampling was conducted during summer 1976, but on a less intensive scale. As a result of the sampling conducted thus far, much useful information has been collected on salinity. However, large areas still exist where data are lacking. In particular, the Blacks Fork drainage, the upper Green River Basin area upstream from Fontanelle Reservoir, and ephemeral and intermittent streams in the plains areas lack salinity data.

The project team believes that if two additional sampling trips, one this fall and another in the spring, could be made it would aid the BLM study group in their determination of source areas for salinity in the Green River. Although the Green River Project hydrologists are quite familiar with the area and have a good concept of source areas for salinity, documentation of the concepts and tying the sampling in to particular land uses is needed.

C. Approach: Two intensive sampling trips would be conducted. One trip would be made during base-flow conditions of October and November; the other trip would be made during spring snowmelt, probably about April. Six hydrologists of the U.S. Geological Survey would participate; up to two BLM hydrologists would also participate to gather first-hand knowledge of the area and the salinity situation.

A helicopter would be used to help gather the data. A fuel truck, two field laboratory vehicles, and a camp trailer would also be utilized. Past sampling trips utilized BLM helicopters from the Boise Fire Center.

Samples would be obtained from springs, flowing wells, and streams. Stream sampling would be done along stream reaches such that increases or decreases in flows or chemical constituents may be located.

Samples at springs and wells would be analyzed for dissolved solids; pH, conductivity, temperature, and discharge measurements would be made in the field. At selected sites, water samples for trace metal and radiochemical analyses would also be collected.

The sampling of streams would involve measuring discharge, channel geometry, and temperature; and sampling for dissolved solids, sediment, turbidity, and biology.

About 570 sites would be sampled and measured. USGS would bear salaries of USGS hydrologists, per diem, lab-truck expenses, and sample analyses costs for trace metal, radiochemical, sediment, turbidity, and biological samples. BLM would bear costs for the helicopter and for dissolved-solids analyses.

D. Report Products: Results of the sampling would be presented in the form of:

1. Maps and map overlays showing locations of sampling sites in the Green River Basin of Wyoming. The map overlays would be at a scale of 1:250,000 and would show:
    a. Locations and identification numbers of gaging stations and miscellaneous surface-water sites.
    b. Locations and identification numbers of ground-water sampling sites.
    c. Location, well depth, and geologic unit of ground-water sampling sites.
2. Tables of data for the above sites. The data would include results of the proposed sampling as well as data that have been collected previously at miscellaneous sites.

3. Histograms of the chemical-quality constituents. The histograms, prepared for different constituents and for different geologic source areas, would summarize sample results and aid interpretation.

4. In addition, members of the Green River Basin Project Team would be available for consultation as needed with BLM hydrologists. In particular, information regarding salinity data gathered during previous sampling trips, and knowledge of the area and its water resources, may be useful.

E. Cost Estimate: (YA-350-08-4340-5225-SS00)

	Fall 1977	Spring 1978
Salinity Analyses (average cost of $50/sample, 285 samples/trip)	14,250	14,250
Total	$14,250	$14,250

Costs of salaries and per diem for six USGS hydrologists, lab-truck and equipment expenses, camp trailer rental, and analyses costs for trace metal, radiochemical, suspended sediment, turbidity, and biological samples will be borne by USGS.

OFFICE OF PUBLIC LANDS HYDROLOGY

I. Hydrologic Modeling

A. Approach: In FY 1978, the Public Lands Hydrology (OPLH) group will be working closely with the hydrologic modeling effort of the Water Resources Division. This effort will be conducted in six basins: North Dakota (2), Montana (1), New Mexico (1), Oklahoma (1), and Alabama (1). OPLH will be collecting data in these basins to test model parameters of soil moisture storage, infiltration, soil detatchability, vegetation characteristics, overland flow, and topographic characteristics, such as slope. These data will be used to develop the model and test it in the experimental basins. The process of conceptualizing the model, understanding the processes and the system, and testing the model in the field is expected to take 3 to 5 years.

B. Reports: In order to make data available to the Bureau of Land Management on a timely basis for environmental assessment studies and leasing, OPLH will complete a progress report on one of the six basins each year beginning in FY 78. This progress report will include the following products:

1. Vegetation and soils map together with interpretations to show pre-mining conditions and post-mining potential for reclamation.
2. Source-area sediment yield maps that represent present conditions.
3. Indexes of erodibility based on soils data and slope representing pre-mining conditions.
4. Infiltration rates, overland flow, and sediment yield data from rainfall simulator experiments.
5. The narrative of the report will discuss plant species that would naturally succeed on a site following a natural catastrophe such as wild fire, species that have been used to replace natural vegetation when shrubs and trees have been eradicated for range improvement, and, as appropriate, recommendations of practices that can optimize soil mositure.

C. Distribution of Funds:

Salaries, Professional and Technical Assistance (Field, Office and Laboratory)	98,000
Travel	8,000
Vehicles	5,000
Supplies and Equipment	1,000
Data Processing and Computer Costs	1,500
	$113,500
WOTSC	22,900
Administrative Service Charge	3,600
Total	$140,000

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